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THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF THE INSTITUTION OF BRITISH FOUNDRYMEN AND THE WELSH ENGINEERS' AND FOUNDERS' ASSOCIATION

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Forthcoming Events.

Institution of British Foundrymen.

London and District Branch.—"Electrical Furnaces in the Iron Foundry," by T. D. Robertson. Visit to Ealing Park Foundry on February 25.

Glasgow Section.—"Cast Iron and its Constituents," by — Turner, on March 26.

Falkirk Section.—"The Smelting of Pig-iron,' by — Anderson, on March 18.

Birmingham Branch.—"Improvements in the Annealing of Malleable Castings," by E. Miller, on March 11.

West of Scotland Iron and Steel Institute.—"The Work of Sorby and the Development of Metallography," by Professor C. H. Desch, on March 17.
—Annual general meeting on April 27.

Institution of Production Engineers.—"Intensive Production of Automobile Bodies," by Mr. G. W. Eastwood, superintendent of the body building department of Arrol-Johnston, Limited, Dumfries, at the Institution of Mechanical Engineers, on February 24.

The Proposed Wedding Present for Princess Mary.

When we inaugurated a scheme for presenting Princess Mary with a wedding present we expressed the opinion that the occasion would demonstrate whether there had been a decline in the art of moulding. Whilst it is still too early to give an opinion on this point, we can say that the art of modelling still has exponents worthy of their forefathers. This is a point which is often overlooked, as some of the most artistic work turned out of foundries in the past and at the present time do not exhibit extreme cleverness in moulding, but rather in the preparation of the models. That is why in the appointing of a committee to deal with the samples, that we have included really practical foundrymen. Mr. Oliver Stubbs, the President of the Institution, has been asked to preside, and Mr. J. Ellis, a past-president, has also promised to assist. This gentleman, it will be remembered, carried off the prize given by the Worshipful Company of Founders some years ago for a casting exhibiting the finer points of moulding. On the artistic side, Mr. F. V. Blundstone, the well-known sculptor, who has designed some of the most important war memorials, has kindly assented to act.

It will facilitate the work of the committee if firms or persons who intend submitting samples, but find the time a little too short, would notify us, saying how many days of grace they would like.

Sanitary Sand Blasting.

This subject was dealt with in a very interesting Paper by MR. E. L. SAMSON at a meeting of the London Branch of the Institution of British Foundrymen held February 9. An instalment of the lecture is printed in this issue. The discussion showed in no uncertain manner that the sanitary aspect of, not only sand-blasting, but of fettling generally left much to be desired. One well-known foundry manager pointed out that "if sand-blasting was the last job on earth, then he would sooner be out of work." Instances were given of the abnormally short lives of sand-blast operators. The present slack period is opportune for foundrymen to consider very seriously the question of drawing up regulations for the purpose of making the fettling department more healthy. It is obviously unfair that the more progressive foundries should tackle this question, which might put up their costs, whilst others can carry on and compete at the expense of their workmen.

It is apparent from Mr. Samson's Paper that the Americans have taken up the question seriously, though, as stated, the problem is still far from solution, especially as regards large castings. It was announced at the meeting by one of the representatives of the Home Office that this Department was investigating the matter, and the opinion of the meeting was that the Institution of British Foundrymen should take up this matter and issue a series of suggestions, otherwise the necessity may arise for the Home Office to take it up for them.

THE LATE MR. C. S. HUNTING, J.P., chairman of the Tyne Iron Shipbuilding Company, Limited, left gross estate of the value of £114,253.

THE UNITED FOUNDRIES, LIMITED, OF MALTON, have placed an order with the Constructional Engineering Company of Birmingham, for a cupola of 7 ft. 6 in. shell diameter.

The Solution Theory of Alloys, with Special Reference to Cast-Iron.*

By Dr. F. J. Brislee.

There is apparently a great difference between a water solution of common salt and cast iron or brass, but it is nevertheless a fact that the correct understanding of the behaviour of water solutions led to the elucidation of the nature of alloys. It is difficult to over-estimate the great importance of this discovery and its influence upon the progress of our knowledge of the nature of alloys.

It was thought that an explanation of the theory of alloys from this point of view might be helpful to the foundryman.

The understanding of this theory renders clear many obscure points in foundry work, and, what is of still greater importance, it provides a weapon wherewith to attack the troubles and difficulties which so often arise.

How Common Salt Solutions Freeze.

Now if we consider, in the first place, a water solution of some well-known salt, sodium chloride, for example, a simple experiment will show that the quantity of salt which a definite weight of water will dissolve depends upon the temperature, but for each definite temperature a given weight of water dissolves a certain quantity of the salt. Tables are given in reference books recording the weight of various salts which will be dissolved by 100 parts by weight of water at different temperatures. These are called "*solubility tables.*"

It follows, therefore, that if the quantity dissolved by a certain weight of water increases with rise of temperature, then if a solution is prepared as strong as possible at a high temperature some of the salt will separate out when it is cooled to a lower temperature. This fact is made use of in the ordinary purification of salts of various kinds. When a solution of salt is prepared, say, of sodium chloride, a dilute solution at 100 deg. C. and cooled down in a tube and a thermometer in the solution. During the cooling the liquid is kept stirred, so as to prevent local cooling. After a time particles of solid will appear, or, in other words, the solution begins to freeze. If the solution is dilute, then the crystals which separate first are pure *ice*, and the remaining liquid portion becomes more concentrated. The temperature at which the first ice appears is lower than the freezing point of pure water; how much lower depends upon the strength of the solution.

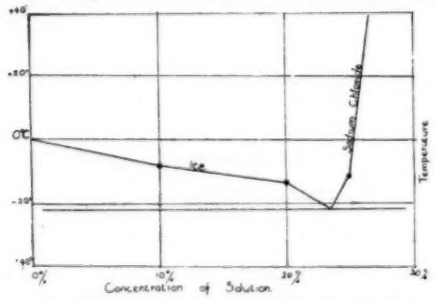


FIG. 1.—SHOWING THE BEHAVIOUR OF SALT WATER UNDER DECREASING TEMPERATURE.

Now if the cooling be still carried on more and more, water separates in the form of ice, and the still fluid remainder becomes more and more concentrated, until such a concentration is reached that it solidifies as a whole. Considering the behaviour of a solution of common salt, it is found by experiment that:—

(1) Pure water freezes to ice at 0 deg. C.

(2) A 10 per cent. solution of common salt begins to freeze at −8 deg. C., and, by continued cooling, more and more ice separates and the remaining fluid portion becomes more and more concentrated, until it contains 23.5 per cent. of salt (NaCl), when it solidifies at −22 deg. C.

(3) A solution which contains 25 per cent. of NaCl begins to separate crystals of solid salt at −12 deg. C., and the remaining fluid portion becomes more dilute until it contains only 23.5 per cent. of NaCl, when it instantly solidifies at −22 deg. C.

(4) Finally, a solution containing 23.5 per cent. NaCl solidifies as an unchanged whole, without separation of either ice or salt. This relationship can be denoted by a diagram, Fig. 1.

Such a diagram tells all the facts about the behaviour of the solution when heated or cooled, and any point on the curve denotes a definite concentration of the solution corresponding to a definite temperature.

How Silver-Copper Alloys Freeze.

The behaviour of such a solution can be compared with the behaviour of an alloy of two metals, such as a silver-copper alloy. The similarity in behaviour can readily be seen by comparing the two Figs. 1 and 2.

The melting point of pure silver is 960 deg. C. Pure silver is separated along the line A B, the liquid portion becoming richer and richer in copper

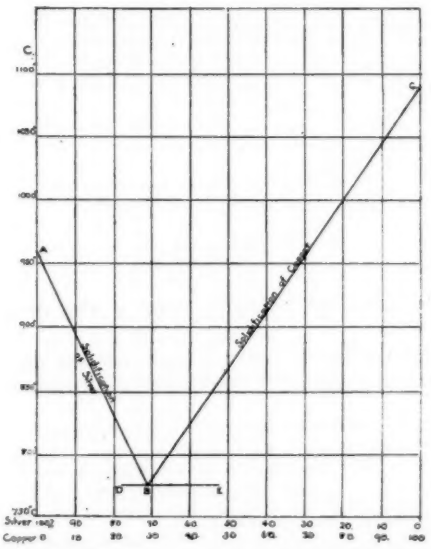


FIG. 2.—SHOWING THE BEHAVIOUR OF SILVER-COPPER ALLOYS UNDER DECREASING TEMPERATURE.

until it contains 72 per cent. silver and 28 per cent. copper, when it solidifies as a single substance.

Pure copper melts at 1.090 deg. C., and the line C. B. denotes the solidification of various percentages of silver and copper until the mixture, 72 per cent. silver and 28 per cent. copper, is reached, when it solidifies as a simple substance.

How Eutectics are Formed.

A dilute and a concentrated solution behave similarly, in that both separate the excess of one or other constituent during the cooling. Thus, a strong solution of salt separates solid salt, and a dilute solution separates solid water until the same concentration is reached from both sides. It may here be pointed out that a solution of salt in water may be looked upon either as a dilute solution of salt in water or a concentrated solution of water in salt.

Referring once more to the common salt-water solution in Fig. 1, it is evident that the final liquid portion has a composition which is independent of the original composition, and thus finally solidifies and melts at a constant temperature. This point is called the *cryohydrate point* in water solutions, or the *eutectic* in case of alloys.

* A Paper presented before the Lancashire Branch of the Institution of British Foundrymen.

The eutectic may then be defined as a mixture of two (or more) metals which have a definite melting and solidifying temperature, and very frequently their melting point is lower than that of either of their constituents.

There is an apparent difference between salt solutions in water and solutions of one metal in another, but there is no real difference, and the laws of one apply to the other. A great many facts have led to the conclusion that solid solutions or solutions in the solid state can exist. Consider, for example, that hot iron will absorb hydrogen, and if hydrogen gas be passed through a red-hot iron tube it will find its way through the walls of the iron. Platinum and palladium both absorb hydrogen in considerable quantities and allow it to spread through the metal. If pure iron be treated with carbon the metal will be found to be penetrated by carbon, although neither is in the molten state.

Microscopic Revelations.

The application of the microscope and the study of metals has shown that profound changes take place in the structure of metals when they are alloyed together.

It is not necessary to describe the preparations of specimens of metals for microscopic examination in detail; suffice it to say that the metal or alloy is polished on a suitable polishing machine,

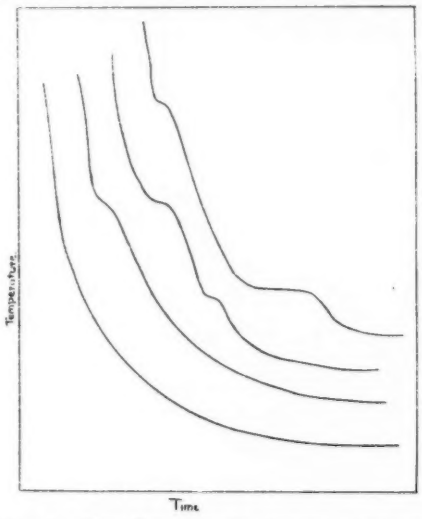


FIG. 3.—TIME-TEMPERATURE CURVES, SHOWING HOW INTERNAL CHANGES BRING ABOUT HALTPANTO.

or by hand, until a level surface, quite free from scratches, is obtained. It is then "etched" with an etching agent, which attacks the different constituents with different degrees of readiness. The specimen is then washed free from the etching agent, dried, and, if tarnished, the tarnish is carefully removed and then examined under a microscope. The difficulty of manipulation varies from metal to metal and alloy to alloy; some are very easy, and in some cases the difficulties are extreme.

Importance of Solid Solutions.

If a series of alloys of two metals A and B is examined microscopically it is found that, starting from pure A and adding successive quantities of B to it, a certain proportion of B can be added to A without changing the form of the crystals of A. This state of things persists up to a definite concentration of B, and then a second form of crystal makes its appearance. This is exactly analogous to the fact that water will dissolve a certain quantity of common salt at 100 deg. C., but if a larger quantity be added to the water it will separate out and remain in the solid state, so *that solution + solid salt are in equilibrium*, the only point of difference being that in case of metals the solution is a solid at ordinary temperatures, and they are called "solid solutions," or "homogeneous solid solutions."

The solid solutions play an extremely important part in modern metallurgy.

If the melting or, better, the solidification, of the metal be followed by means of a thermometer or pyrometer additional evidence can be obtained as to the nature of these solutions. Consider the cooling of a substance which undergoes no change of state, *i.e.*, does not solidify—for example, a piece of platinum heated to about 1,400 deg. C., which is below its melting point—and suppose that readings of the pyrometer are taken at definite time-intervals. The results can then be plotted on a curve, and a smooth curve will be obtained (Fig. 3.) In the second case, suppose the cooling of a mass of molten metal, such as pure copper, the cooling being followed in the same way. At first the cooling takes place rapidly, then there is a halt for a few moments while the mass solidifies, and then the cooling takes place regularly once more. If the same series of observations are taken for an alloy like silver-copper, or lead-tin, the cooling curve of alloys containing less than 45 per cent. copper and 55 per cent. silver, or less than 76 per cent. silver and 24 per cent. copper, will show only one halt point, but for alloys containing from 55 per cent. to 76 per cent. silver a second halt point makes its appearance. This corresponds to the solidification of the eutectic.

In the same way if pure electrolytic iron be melted and heated well above its melting point a halt is found to take place at about 1,600 deg. C., corresponding to the melting point of pure iron; the cooling then proceeds regularly until two other halt points are observed. The first is called A_3, and is about 890 deg. C, and the second takes place at about 770 deg. C, and is called A_2. These changes correspond to changes in the thermo-

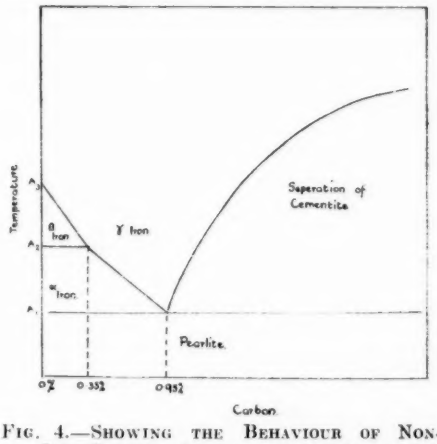


FIG. 4.—SHOWING THE BEHAVIOUR OF NON-IRON-CARBIDE ALLOYS WHEN COOLED FROM THE LIQUID STATE.

electric properties of iron; above A_2 iron is non-magnetic, below A_2 it is magnetic, and the iron is now known to exist in three allotropic forms, viz., γ iron stable above A_3, β iron stable between A_3 and A_2, α iron stable below A_2.

Still further investigation shows that these points vary with the amout of carbon.

How Carbon Effects tha Cooling of Iron.

Iron shows a great tendency to combine with carbon and also to dissolve carbon, when the iron is in the molten condition. In the ordinary blast furnace method of iron production from the ore the ore is placed in the furnace together with coke and limestone. The ore, which is chiefly oxide of iron, is reduced to metal, and the hot molten metal coming into contact with carbon in the form of the fuel and in the form of gas as CO and CO_2 dissolves a considerable quantity of carbon. Part of this carbon is dissolved in the metal as carbide, but much is rejected on cooling as graphite-like plates, whilst a part remains combined with the iron as iron carbide, which remains dissolved by the molten iron, and even after solidification.

In ordinary grey pig-iron the combined carbon is low and the free or graphitic carbon is high, 3.0-3.5 per cent. and even higher; white iron, on the other hand, contains the carbon, almost wholly as combined carbon—that is, as carbide of iron dissolved in an excess of iron, or a solid solution of carbide of iron in iron.

C

The product of the blast furnace—grey cast iron—contains, in addition to carbon, small and varying quantities of silicon, manganese, phosphorus and sulphur, all of which modify the properties of the resulting iron, and confer some desirable and some undesirable characteristics upon the metal. By judicious blending of different brands and grades of iron, according to their analyses, it is possible to obtain cast iron with different strengths and suitabilities for different purposes.

Cast-Iron Regarded as a Carbon-Iron Alloy.

For the present cast iron will be considered as a carbon-iron alloy, and for sake of simplicity the influence of the remaining constituents will be ignored, or, more correctly, assumed to be present in such small amount that their influence upon the properties of the iron is negligible.

If cast iron is considered in this light it becomes evident that the proportion of carbon which will dissolve in iron at different temperatures is an important constant. Now iron at a high temperature will dissolve a large quantity of carbon; and just as a solution of salt in water which is saturated at 100 deg. C. will separate solid salt when it is cooled to 15 deg. C., so the iron on cooling will separate carbon in the form of plates of graphite as it cools down. It has been shown that molten iron at its melting point dissolves 4.3 per cent. carbon to form carbide. It should be pointed out in passing that the solubility of carbon in iron is influenced by the presence of other metals, *e.g.*, both manganese and chromium increase the solubility of carbon in iron. On the other hand, silicon, phosphorus, sulphur and aluminium diminish the solubility of carbon in iron.

Various Forms of Carbon in Cast-Iron.

Further, it is evident that carbon can exist in several different forms in the resulting iron:—

(1) As graphite in hexagonal plates, which is left behind when the iron is dissolved away in hydrochloric acid. The graphitic carbon content is greatly influenced by rate of cooling.

(2) As carbide of iron, Fe_3C, which contains 93.34 per cent. iron and 6.66 per cent. carbon. The formation of carbide is favoured by slow cooling and hindered by rapid cooling. The carbide carbon plays an important part in the heat treatment of steel.

(3) Temper carbon is formed when iron poor in manganese is subjected to long annealing at a temperature above that required to form the carbide, but below that necessary to produce graphite. The temperature is 720-850 deg. C., and the change is favoured by hammering. Tempering carbon is often produced when iron is softened by annealing.

(4) Hardening carbon. This form is dissolved in iron, uniformly distributed, but in variable amount.

All fluid iron contains hardening carbon only; when it solidifies it produces graphite, then carbide, and, by long heating, temper carbon. If the iron containing the above varieties of carbon is melted the solution of the constituents takes place in the reverse order.

Finally, it is a point of interest to note that Moissan prepared diamonds artificially by saturating molten iron at a high temperature with carbon, rapildly cooling the mass, and then removing the excess of iron by solution in hydrochloric acid.

How Constituents Separate when Cooling Cast-Iron.

The various forms of iron which separate as the metal cools are:—

Pure iron, which can exist in three allotropic forms, is termed "ferrite," the three allotropes being distinguished as α, β and γ ferrite.

The separation of *ferrite* is strictly analogous to the separation of ice from the common salt solution.

The carbide of iron Fe_3C is called *cementite*.

The eutectic is known as pearlite, and contains about 0.89 per cent. of carbon. It is looked upon as a mixture of cementite, 14 per cent. and ferrite, 86 per cent.

The general form of the equilibrium diagram is shown in Fig. 4.

This is based upon two conclusions of Goerens, who made a very important advance in the development of the diagram, and showed that:—

(1) The carbon in molten iron is in solution as carbide.

(2) The system must be considered strictly to be one of iron-iron carbide.

It is evident therefore that the molten metal which collects at the bottom of the blast furnace consists of a saturated solution of iron carbide in iron. As the molten iron cools carbide is thrown out of solution, and, being unstable, it dissociates into iron and carbon with the separation of graphite.

As the iron freezes the eutectic splits up into solid solution and carbide, and the latter persists or dissociates, according to the rate of cooling and other conditions.

The pearlite can then change into carbide and free iron, and the carbide, dissociate with separation of graphite, producing perfectly soft iron, free from combined carbon, or the combined carbon will persist and produce a harder iron.

Cupola Changes.

The changes in ordinary cupola melting are very similar to those which take place in the blast furnace. The charge of pig-iron which is introduced is melted with suitable additions of scrap, etc., so as to give a product with the requisite composition and properties. As the metal melts it comes into contact with the strongly heated coke, and it dissolves more or less carbon; how much depends upon the time the metal and fuel are in contact. The metal which collects at the crucible of the cupola, and which is tapped out, may not be saturated with carbon. The influence of the other constituents of the iron, silicon, manganese, etc., all exert an influence upon the solvent power of the iron for carbon, and by constant conditions and careful selection of materials according to analysis iron suitable for different castings can be obtained.

So far, the general theory of the nature of cast iron has been dealt with, and the clear understanding of this is the key to the gate of the road along which progress may be made. It will therefore repay a careful study and mastery by each one engaged in foundry work.

Methods Necessary for Elucidation.

The question may now be asked, How are these facts elucidated? And the answer is by aid of the microscope and by aid of the pyrometer and chemical analysis. The methods of thermal analysis, which depend upon the rate of cooling of the same quantity of each alloy under similar conditions, show the proportions of the various components and phases which separate during the cooling from each alloy. A short consideration will make this clear. Suppose a quantity of a lead-tin alloy containing lead and tin in the eutectic proportions is allowed to cool from a temperature well above the melting point of the mixture, *e.g.*, 350 deg. C. The cooling takes place regularly until a temperature of 180 deg. C. is reached, when the alloy begins to solidify and the latent heat of fusion is evolved. This tends to keep the temperature constant, or, expressed in other words, there is a halt in the cooling curve. Now this halt will exist for the longest time for the eutectic mixture, and when the composition of the alloy differs from the eutectic there will be two halts, one corresponding to the separation of the pure metal, the second to the solidification of the eutectic. The time of the existence of the second halt will be proportional to the quantity of eutectic present, provided that the conditions of the experiment are kept constant.

The results are plotted with the length of time of halt at the eutectic point for the ordinates and the percentage composition of the alloy for the abscissæ. In this way a diagram is obtained which shows the quantity of eutectic present at any definite mixture of the two metals.

Ascertaining Eutectic Points.

The eutectic compositon is determined by making a series of melting point determinations of alloys of varying mixtures of the constituents, and the microstructure of these alloys is also determined. Consider two metals A and B. The melting points of A and B will be first determined, and then a small specimen of each will be examined under a

microscope. Mixtures of A and B in varying proportions, by steps of, say, 10 per cent., are examined in the same manner, and the separation of one constituent on the other can be seen under the microscope. The eutectic composition has always a fairly definite and characteristic structure, and the separation or disappearance of one or other phase will be clearly evident. This, added to the single halt point on the cooling curve, proves the eutectic point.

Observations are then made so as to fix the composition more exactly, by examining mixtures of the metals which differ from each other by only a small percentage until such a composition is reached that no separation of a second constituent takes place, or, in short, the alloy behaves as though it were a single substance.

The composition of each alloy must be settled by analysis, it being inaccurate to rely upon the composition from the mixture fused. The losses by oxidation, etc., *i.e.*, pit losses, cause errors which are best corrected by analysis.

Variables.

The variables in all classes of work upon alloys in the foundry are temperature composition, rate of cooling. The composition is liable to vary with loss due to oxidation or too high a casting temperature, unknown compositions of scrap metals, but by careful use of accurately analysed material these can be avoided and the composition kept constant. The rate of cooling is much more difficult to control, even though the casting temperature is constant. The rate of cooling depends upon the shape of the mould, the moulding sand, the moisture content of the sand, and the external temperature of the air. If iron is saturated with carbon when molten and suddenly chilled, so that the carbide cannot dissociate into carbon, pearlite, and hard castings may result owing to a high percentage of combined carbon.

Slow cooling, on the other hand, will lead to separation of carbon in the form of graphite, and may result in porous castings, especially when the graphite segregates into spots.

It therefore follows that a consideration of the conditions of a cast will furnish a certain amount of guidance in the avoidance of faulty castings and in remedies for faults. A certain amount of guidance only, because there are so many variables that it is almost impossible to control all at once. Nevertheless, the assistance given by these facts proves useful in providing a means for attacking a problem and for avoiding a failure.

Malleable Cast-Iron.

The French metallurgist, Réaumur, discovered a method of softening cast iron by heating iron castings embedded in oxide of iron. This is the basis of the English method.

The American or Blackheart process involves not only the elimination of some of the carbon, but also the change from the combined to the free state; the free carbon forming a kernel, which is black, hence the name.

The production of malleable cast iron necessitates the use of white and mottled irons. The interest for the present purpose is the removal of carbon from the solid iron by means of the oxygen of solid oxide of iron. It is an excellent example of a chemical reaction taking place in the solid state. It is found that the removal of carbon takes place not only in the portions in contact with the oxide of iron, but even into the interior, provided the heating is continued for a sufficient time. It is customary, however, to decarburise to a certain depth only, depending upon the use for which the castings are designed. The process by which the decarburisation takes place is probably the first formation of carbon dioxide from the carbon and oxide of iron at the surface of the casting; this gas penetrates the casting at the high temperature, and the carbon dioxide becomes changed into carbon monoxide by the carbon in the interior.

The Chemistry of Malleablising.

The carbon monoxide then passes to the surface of the casting and, coming into contact with the oxide of iron, becomes again converted into carbon dioxide, and the cycle proceeds:—

$$2Fe_2O_3+3C=4Fe+3CO_2.$$
$$CO_2+C=2CO.$$
$$Fe_2O_3+3CO.=2Fe+3CO_2.$$

The exact mechanism of the malleablising is not entirely clear, and it is unnecessary to discuss at present the various theories proposed, but to give some brief idea of the chemical reactions involved in the process. It might here be pointed out that according to one theory the carbide must be dissociated and carbon precipitated as annealing carbon before it can be eliminated; the other theory holds that this precipitation is unnecessary.

It is well known that to produce malleable castings it is not essential to eliminate the carbon, but only to precipitate it, *i.e.*, to decompose the carbide or cementite.

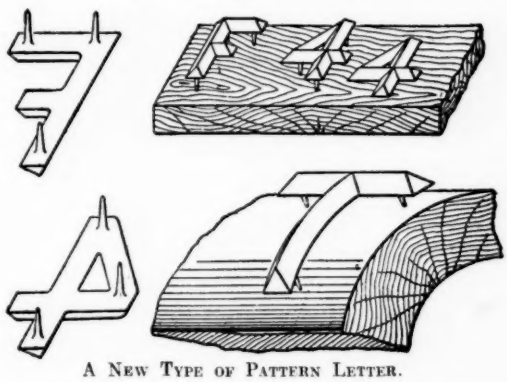
It seems highly probable that both reactions take place in the English and American methods, but to different extents.

The interesting point is the ease with which carbon can be eliminated in the solid state, and it is another instance of penetration of a solid metal by a gas which passes in as CO_2 and out as CO.

Maughlin Pattern Letters.

A new type of pattern letter has recently been placed upon the British market by Messrs. C. A. W. Mitchell & Company, of 142, West Regent Street, Glasgow. The letters go by the trade name of Maughlin and are made of aluminium. They are die cast, and then provided with pins from ¼ to 2 in. long. Only one type is made—the sharp face Gothic, which is probably the best type of letter to use.

The outstanding advantages of this type of letter are its depth and taper, this latter being sufficient to ensure a good draw, which obviously makes for clean lettering on the casting. A distinct saving is shown, as against the old-fashioned white-metal letter which is attached to the pattern with shellac, and very often falls off in the sand,



A NEW TYPE OF PATTERN LETTER.

resulting in a casting with some letters of the inscription missing. Such letters are easily knocked, and, as they are usually of the flat variety, they do not give such good results.

Stamped brass letters have usually to be attached to the patterns by means of brads or tacks. This, of course, takes up time, and the results are little better than white-metal letters. The pins, which are cast on the Maughlin letters, are strong, and stand up without difficulty to being driven into mahogany, which is one of the hardest woods used in pattern-making. The type of letter described above is illustrated in Fig. 1.

A SETTLEMENT has been reached between the Joint Committee of the Light Castings Trade Unions and the Light Castings Employers' Association on the question of the piece-work wages of apprentices. The terms are to the effect that the wages of apprentices under 18 years of age be reduced as from February 6 by 3s. 3d. per week, and in the case of apprentices over 18 years of age a reduction of 5s. 6d. per week will also take effect as from February 6, with a further reduction of 5s. 3d. as from March 20. The whole of the trades in the light castings industry throughout England and Scotland are affected by this settlement.

XUM

Castings for Internal Combustion Engines.

By Ben Shaw and James Edgar.

CRANK-CASE.

(*Continued from page 87.*)

The Moulding

The production of castings for crank-cases taxes the ingenuity of the moulder and founder to at least an equal degree as any other castings required in the production of internal-combustion engines. With this type of casting lightness is of considerable importance, hence an alloy of aluminium is preferred, and it is the difficulties experienced in producing castings in aluminium which calls for that skill and ingenuity in the preparation of suitable moulds. The high contraction of this metal is the principal cause of trouble to the moulder, and, as it is hot short, the mould must be so formed that it will crush under comparatively light pressure from the contracting metal. It is the disregard of this important factor which causes the high percentage of wasters in connection with aluminium castings. When the resistance to contraction is too great the castings crack and become useless, the strain being carried in them to a much less extent than with cast iron or steel. The high shrinkage of this metal makes it very desirable to have a regular thickness in the casting. Abrupt changes in the metal thickness are another source of trouble to the moulder, and should be avoided wherever possible, as the irregular sections not only tend to draw and cause spongy metal, but set up unequal strains during the time of cooling. Though a regular thickness of metal in any one casting is desirable it is rarely possible so to design the work; it is, therefore, the duty of the moulder to endeavour to equalise the cooling of the casting and introduce suitable feeders from which the heavier sections can draw metal when they are cooling. To assist the heavier sections to cool more rapidly denseners have and are being used with considerable success, so much so, that their use has developed into a necessity.

Denseners.

These denseners are composed of some metal having a higher fusing point than the metal to be used for the casting, and as its main value is to reduce the temperature of the molten metal quickly it should be a good conductor of heat. Pieces of copper are more frequently used for this purpose in connection with aluminium castings. They are made flat or curved according to the shape of the casting at the place where they are inserted into the mould. It is preferable to have these made in advance so that they can be bedded into the sand during the ramming-up. Discretion should be exercised in the use of these denseners, and where it is possible to feed a heavier section it is preferable, though there is much diversity of opinion on the respective value of each.

Preparation of Moulds.

The method of preparing moulds for the type of crank-cases illustrated varies according to the number of castings required and the facilities available. In some foundries, particularly those badly equipped with modern moulding machines, the practice is frequently adopted of casting the joint flange down with the idea of getting sound metal in that flange. The drag in such a method merely carries an impression of the facings and the core-prints. In some cases only a two-part box is used, but generally three parts are preferred. More modernised foundries, however, prefer to cast the joint flange uppermost, and only a two-part box is then necessary. It may be an advantage to compare the two methods and consider the reasons made for the preference shown. With the joint flange cast down the majority of the cores project above the drag, and thicknesses are considered to be more easily checked. Should the cope carry all the rest of the mould then special guide pins must be used; but, whatever precaution may be taken, there is always a great risk of crushing. To reduce this difficulty another part is employed, and a tapered joint made down to the surface of the pattern; this reduces the possibility of crushing.

The method is costly and is not so convenient for adoption on a machine as it would be with the joint-flange moulded-up. It has one important advantage and that concerns the running of the job. In pouring aluminium it is now recognised that it is important to avoid turbulence of the metal in the mould as it breaks the thin film of oxide which is formed on the surface, part of which becomes imprisoned in the casting and more oxide is formed to cover the surface of the metal. It is because of this fact that aluminium castings are preferably cast from the bottom; thus with the large flange of the crank-case cast down, it is in a very convenient position to have runners prepared on the joint. The method of preparing such a mould with a three-part box is indicated in Figs. 1, 2 and 3. A bed is prepared on the foundry floor and the pattern bedded in until the flange has a bearance, then a middle part is located over it as shown in Fig. 1. Sand is rammed about the pattern and a joint made as indicated in Fig. 3; but over the supports A and B, Fig. 1, it is better to prepare for drawbacks to carry the cores, so that they can be set separately as shown in Fig. 2. A cope-box is then set and rammed up to take the top impression, then the two parts are rolled over and the drag part rammed up last. Stripping is commenced from this position. While this method is adopted in some foundries we do not suggest that it is the best and most economical; as a matter of fact, castings of this type can be

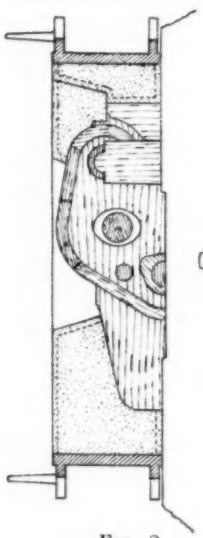


FIG. 2.

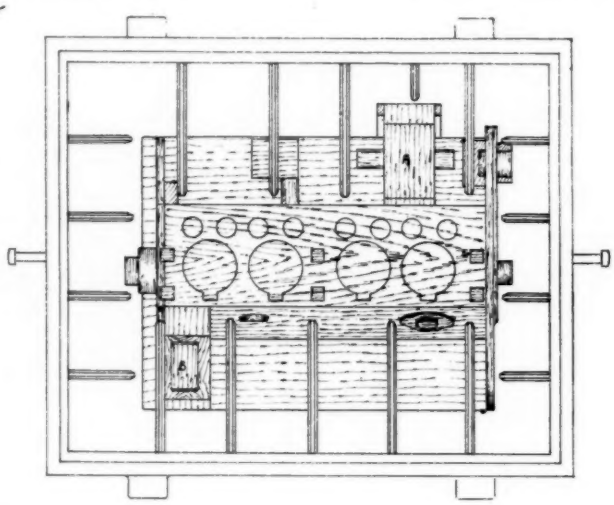


FIG. 1.—MOULDING FLANGE-DOWN.

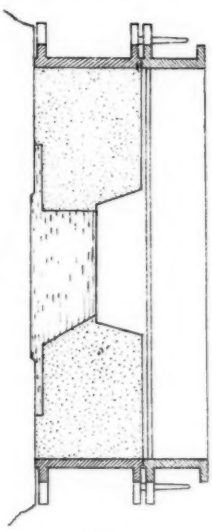


FIG. 3.

turned out rapidly on a machine, and the method of casting the large flange uppermost increases the ease with which this can be accomplished.

Moulding Flange-up.

Whether a machine is used or not, however, this method of casting possesses advantages over the previous method, which is recognised by its more general employment. In the first place the drag takes practically all the mould, and, with two minor exceptions, all cores are set in the drag and their surfaces are flush with the joint, each core being capable of being set into its relative position with very little likelihood of them becoming moved or crushed when locating the cope. The square-cored openings over the bolt-hole bosses are then in the bottom, which leaves the top clear for using risers. Figs. 4, 5 and 6 show the type of box-part used and the manner in which the mould is prepared. In this instance a solid box-part is illustrated, though frequently frame-boxes are employed having bars secured separately to suit the work; when many castings are required, however, it is better to prepare special boxes. When the moulds are to be prepared on the foundry floor journals should be cast in the ends of each box-part to facilitate turning over, but if they are prepared on a machine with a turning-over device then these journals are not necessary. It is important to remember that the casting is to be in aluminium, and the box-bars should be sufficiently clear to allow the sand to move while the casting is contracting.

It is necessary to prepare a bed when using the floor, so that the pattern can be set in an inverted position upon it, or a framed board will answer the purpose better and be more economical; in either case, the flange of the pattern should come in contact with them for the joint. Fig. 4 shows the pattern set on the prepared bed in an inverted position with the drag part located over it ready for ramming. Fig. 5 is a section through A, A, showing the relation of the pattern with the bed on the floor.

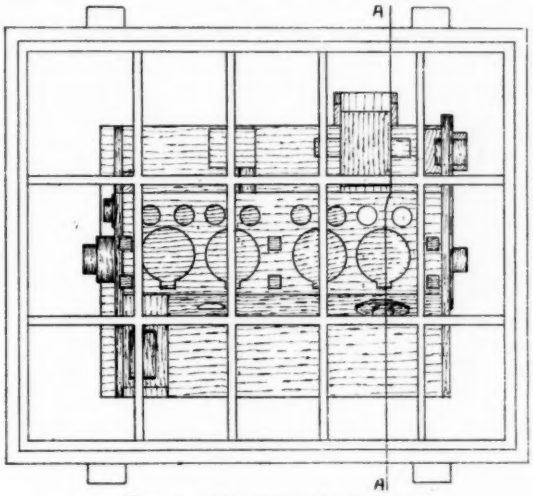


FIG. 4.—MOULDING FLANGE-UP.

Tempering the Sand.

Considerable attention must be given to tempering the sand for aluminium moulds, the amount of water it contains being just sufficient to make it cohesive. There are a few reasons why this should be specially mentioned with reference to this class of moulding; it becomes more quickly disintegrated after the metal is poured, therefore, it gives the casting more freedom to contract. The sand is more porous when it contains less moisture, and pressure against the casting is reduced. When the moisture is unevenly distributed in the sand there is a tendency to get damp places on the face of the mould, and these cause sponginess in the casting, aluminium being very active in a molten state it decomposes the water and absorbs some of the gases. With sand of the desired consistency the drag can be rammed. Care must be exercised in this operation, and to give the best results the sand should be lightly rammed, sufficient to take the impression and capable of withstanding the rush of metal when casting. Those familiar with the density required for iron castings in green sand will realise that the sand need not be so dense for aluminium as less pressure is exerted, and it is desirable that these moulds should be more lightly rammed so that the sand will crush with less strain upon the casting.

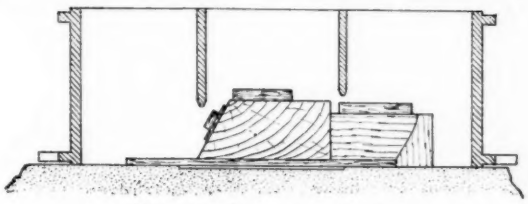


FIG. 5.—SECTION ON A, A.

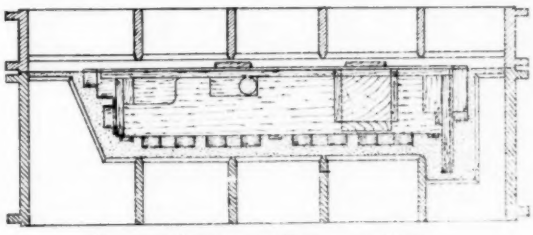


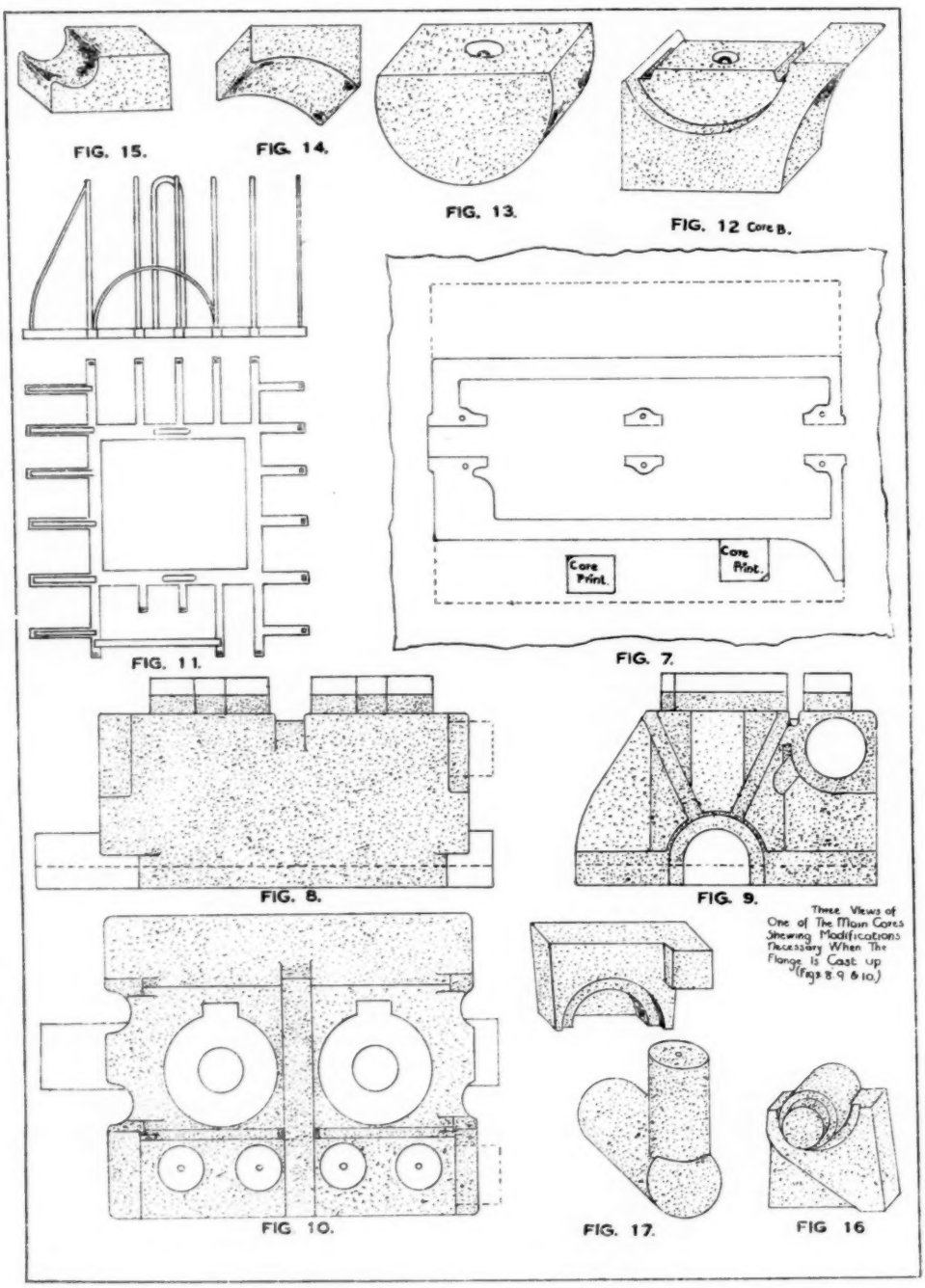
FIG. 6.—SECTION OF DRAG AND COPE.

Pouring Difficulties.

When the flange is cast up in the manner shown it is more awkward to adopt bottom pouring. In some cases moulders prefer to have one end blocked in and a core made to carry the shape and also suitable sprues from one large runner. When hand ramming is resorted to a prepared runner is sometimes introduced during the time of ramming, a gate being set to coincide with it when commencing to ram the cope. Many obtain good results from a spray supplying metal to the side of the top flange, and this method is frequently adopted for machine moulding because of its convenience. Whatever method is adopted, however, it is important to bear in mind that to obtain satisfactory results it is necessary to arrange them in such a way that the agitation of the metal due to pouring is reduced to a minimum.

The drag having been rammed is turned over and the cope part located, as shown in Fig. 6. It will be noted that when the flange is moulded up the cope is almost flat, therefore only a shallow box part need be used. Whilst care is necessary in determining the method of running, it is equally essential in the setting of risers. All thicker parts of the casting which have direct contact with the top flange should have some facility for being fed, those parts not in contact with the top should be attended to, either during the ramming of the mould or in the preparation of the cores, whichever are affected. On the top flange it is necessary to set risers over the bolt-hole bosses at each side of the bearings, and they should be about the same size as the bosses themselves in order that they feed the casting and do not draw. When these have been set and parting sand applied the cope can be rammed.

Castings of this type are usually wanted in quantities, and it is more economical to prepare the moulds on machines. When the pattern is prepared for moulding the flange up this is not a very difficult matter, as it can be quickly fixed to suitable plates. The main body of the pattern can be secured to a wood or metal plate, the facings and prints being removed so that the



flange comes directly in contact with the plate. The pieces which have been removed will need to be secured to another plate, upon which the cope is to be formed; it is important, of course, that the parts be set in their true relationship, so that impressions taken from each will coincide when they are brought together. When the pattern work is specially prepared for the machine, then the cope-plate will carry the facings and prints similar to that indicated in Fig. 7, and guide holes for the risers are an advantage. The plate for the drag will carry the runner and sprues to form the spray for running the job. Apart from the economy, there are other advantages in using a machine for this class of work, particularly when a jolt-ramming machine is used; the density of sand is more uniform, and it is more porous than when hand ramming is resorted to, and the jolt can be varied to give the required density much more readily than is possible when the human factor is depended upon.

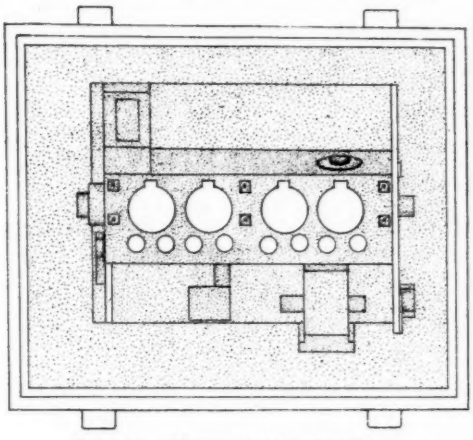


FIG. 18.—MOULD AFTER STRIPPING.

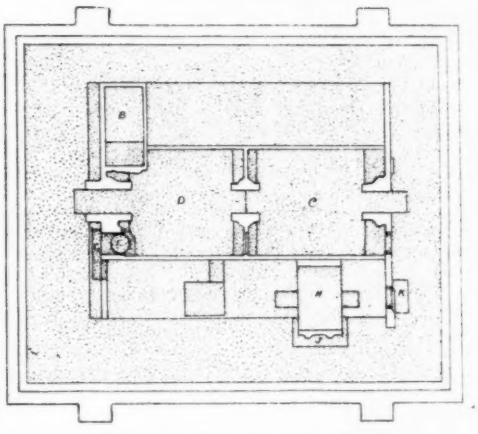


FIG. 20.—LOCATING THE CORES.

Core-making.

Special attention must be given to the production of the cores for aluminium castings, particularly when they are large and almost surrounded with metal. They should be easily disintegrated by the heat of the metal and very porous. Naturally, bonded sands are not sufficiently reliable; their strength varies, therefore their resistance to crushing is not constant. It is better to use an artificially bonded sand, and either glutin or linseed oil will do well as a bond. The majority of the cores required for this crank-case can be made on a jar-ramming core machine, and a more freely-venting core is produced than by any other method.

One of the main cores is shown in Figs. 8, 9 and 10. The illustrations are shaded in to show the formation of the core when the flange is cast down; when casting the flange up, however, it is possible to carry many of the small cores on the main core. The dotted lines along the bottom of Figs. 8 and 9 and the added portion on the top of the core show the difference for the prints, but the bearing cores and the round cores BB can be formed as part of the main core when casting a flange up. The type of grid suitable for these main cores is shown in Fig. 11. It is not desirable that the grid should be too rigid, and pieces of wrought iron may be introduced with advantage. A slight variation from this form is necessary when the casting is made the other way up, the main point to remember, however, is that only sufficient strength is necessary to enable it to support the sand and allow it to be lifted. However well the sand may be rammed, if the grid is too rigid it will offer considerable resistance to the metal after it has been cast; this is a frequent cause of wasters. Figs. 12, 13, 14, 15, 16 and 17 illustrate some of the other cores required.

When the gate and risers have been removed from the cope after it has been rammed up, the box parts can be separated and the pattern withdrawn. If the pattern is good, as it should be for this class of work, it should deliver with very little difficulty, whether it is withdrawn by machinery or by hand. The better the delivery the less the tooling required. With a stripping machine there is rarely any necessity for sleeking off, but when the operation is done by hand there is usually some tooling necessary.

Mould Facings.

Many foundries make a practice of facing their moulds to give a better skin to the castings. A mixture of powdered soapstone and plumbago is very suitable for this purpose; it is, however, preferably applied with a camel-haired brush rather than being dusted on, as the whole surface can then be covered.

Coreing-up.

When this has been done and any surplus blown out, the operation of coreing up can be commenced. It is in this operation that the skill of the pattern-maker is so often questioned; rarely, indeed, do the cores for a complicated job fit together without some slight rubbing. It is much more satisfactory to make a dummy set of cores in the first place, and assemble them so that they can be tested for accuracy, then any discrepancy can be remedied. If this procedure was more frequently employed before the pattern was sent to the foundry much trouble and expense might be saved. Locating and setting the cores in the first mould always takes more time; any difficulties or peculiarities must be surmounted with the first one, and the methods used merely recur in the rest. A plan of the drag is shown in Fig. 18, showing the small square cores AAAAAA for the bolt heads, and which are the first to be introduced. Fig. 19 is composed of a number of sections to show the shape of the mould at different parts.

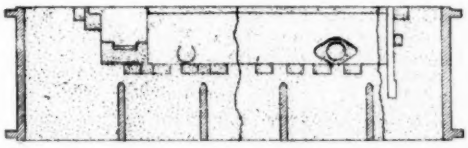


FIG. 19.—SECTIONS OF MOULD AT DIFFERENT PARTS.

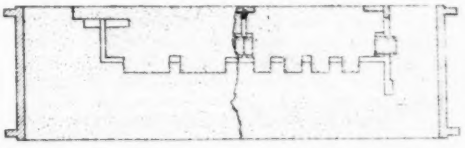


FIG. 21.—SECTIONS OF THE ASSEMBLED MOULD.

Considerable care is necessary in placing the cores so that once they are set there is no need to remove them. After the square cores, the core shown in Fig. 12 should be set, indicated by B in Fig. 20. Then, after small subsidiary cores have been set in the ends of the mould, the main cores C and D can be located. The subsidiary cores should be just clear of the main cores, so that they can be inserted without the risk of displacing them. The cores shown in Fig. 17 may come next in the order of rotation; these are

shown at E and G in Fig. 20. The core G. it will be noted, secures the core E, and at same time cuts through the end flange to provide access for machining purposes. The remaining cores H, J and K can next be inserted in the order given. It is essential, when setting these cores, to be quite sure that their surfaces are flush with the joint of the mould. Two sectional views of the mould with the cores in position are shown in Fig. 21. There are still two cores to be located—those shown in Figs. 14 and 15; they are inserted in the cope, and since it is possible to insert them the wrong way, unless the print is checked out to prevent it, it is necessary to be sure when setting. These cores need to be wired to the cope. A couple of chaplets should be set on the core B before closing, and though it may be considered necessary to try clays when closing the first mould, it is not essential afterwards; providing all precautions are taken, it is not necessary at all. Runner and risers require to be provided for when the job is closed and the boxes clamped for casting.

Metal Considerations.

While every care and attention may be given to the production of the moulds to secure sound castings, the metal to be poured into them influences the character of the castings to a marked degree. Its temperature is a very important factor; it should be as low as possible, certainly no higher than will give the necessary fluidity for running the job. The molten metal should show the metallic lustre after the dross has been removed and not be red hot. If the temperature of the metal is too high, it can be reduced by adding cold metal without materially affecting its quality. The alloys for this class of work vary in their contents of zinc and copper, and, as far as possible, a reducing atmosphere should be employed to melt these alloys. Special furnaces are now used for aluminium, and they are preferably fired by either gas or oil, which are more easily regulated. It is better if the flame does not come in contact with the metal, but when large quantities are required this cannot be avoided, hence there is considerable loss of metal due to oxidation. Charcoal cannot be used to protect aluminium by creating a reducing atmosphere, because it is absorbed to form a carbide of aluminium, which shows in black patches on the casting. Zinc chloride is useful for reducing the scum which collects on the surface, but frequently common salt, together with a little fluorspar, is used for the purpose. The metal should be poured quickly, maintaining an even flow to reduce the agitation as much as possible.

Position of the Shop Foreman.

At a recent meeting of the Manchester Association of Engineers, Sir Henry Fowler initiated a discussion on the above subject. In the course of his remarks Sir Henry said :—" In times past we have looked upon the foreman as being a representative of the management in the shop, whom the workman looks upon as being the visible sign of his employer, and I think we shall agree that it is absolutely necessary that this feeling should continue."

Dealing with the question of wages, discipline and shop organisation, Sir Henry pointed out that :—" This entirely depends upon the size of the shop and the character of the work. Each shop must be entirely judged from its own particular standpoint, but in all cases where any change is to be made every effort should be exercised to carry the foreman with the management. It is only human that we none of us like to have work or position taken from us, and there undoubtedly arise cases in certain shops where details such as those mentioned are much better handled by an expert. I feel that in all cases the discipline of men, except as far as punishment is concerned, should be carried by the foreman, and that he should be consulted before any material change is made in the shop or any alteration in operation in the shop; further, that, as far as possible, all instructions should be given through him. In fact, everything should be done to strengthen rather than depreciate his position, whilst at the same time advantage should be taken of the particular knowledge the special inspectors possess on various points.

" A foreman has special facilities for studying not only the shop but its occupants, and the knowledge thus obtained is of the greatest value if we can only devise a proper means for using it. One important point is the selection and training of foremen. The latter is naturally a matter of very great difficulty if the shop is of any size, and there are assistant foremen—the same difficulty arises with regard to them—as it is a considerable step even from the charge-hand to one who, as is stated, is a representative of the employer in the shop. All one can say here is that we have to look over men of character and to see that their character above all things contains tact.

" I came across the following definition of tact the other day, and although it may not be absolutely correct, I think it puts in a fairly concise form the best definition I have seen. It is as follows :—

" ' Tact is a science to the feelings, a considered method whereby a man's judgment may be overruled. It is a deference to the sensibility of man rather than to his intellect. Who, then, is bold enough to say that men are guided by their judgment rather than by their feelings? Were this so we should have no place for tact.'

" It is this want of deference to the sensibilities of men that causes so many otherwise fully qualified men to be unsuitable for management in any firm. Before I had seen the other definition I had said that tact may perhaps be taken as quick realisation of the other man's character and point of view, and immediate action with the knowledge of this, if not wholly in accordance with it.

" By training and education we may force a man to be industrious, to possess technical knowledge, to see the advantage and necessities of loyalty both up and down, to cultivate quickness of view and of thought, but we must have a good basis of tact in character, and also of imagination if we are to get the best results from a foreman.

" Some time ago I saw it stated that one of the greatest benefits of holidays was to allow us to try various men as foremen and assistant foremen, and I think this is absolutely the case. We all of us know of instances where a man, as far as we could judge, gave promise of becoming a most excellent foreman, and yet we find when he is put into a position of authority he does not rise to it at all.

" The position of under-foremen follows very largely in the remarks above. One trouble, however, is with regard to the management keeping in touch with these men. It is a matter of very considerable difficulty, as when in the shop one naturally deals with the head foreman, and although when the latter is absent the opportunity is given, yet I felt that in addition to this every effort should be made to see the under-foremen and encourage them in their work.

" The coming of works committees has made a considerable change in the relation of the foreman and men under him. Where these committees are of a formal nature the foremen must be represented when discussions take place on subjects pertaining to their own shops. They must be made to appreciate that the discussions are on and along broad lines, and must feel that the shop committees have not been established with a view of being derogatory in any way to their prerogative."

Pig-Iron in January.

According to the National Federation of Iron and Steel Manufacturers, the production of pig-iron in January amounted to 288,000 tons, a figure higher than in any month since March last, but less by 354,000 tons than the production in January last year. The furnaces in blast at the end of January numbered 90, compared with 77 at the end of December and 242 at the corresponding date last year. Of the production of pig-iron in January, 102,900 tons were hematite, 84,700 tons basic, 68,300 tons foundry, and 16,900 tons forge. The production of steel ingots and castings in January showed a further decline to 327,500 tons, compared with 381,000 tons in December and 443,800 tons in November.

Semi-Steel.

At a meeting of the Sheffield Branch of the Institution of British Foundrymen, held on January 20, Mr. John Cameron, of Kirkintilloch, Scotland, gave an address on "Semi-Steel." Mr. John Watson presided.

Mr. Cameron, in opening, alluded to the unfortunate name, "Semi-Steel," as misleading. Some of them would remember that about twelve months ago the Editor of THE FOUNDRY TRADE JOURNAL gave this subject great prominence, calling attention to the misleading name, and suggesting "Fontoid." This was a step in the right direction, but he thought it rather artificial, and that it was possible for the combined brains of the Institution and the British Cast Iron Research Association to find a satisfactory name for semi-steel.

As ironfounders they were to-day being called upon for better quality of castings, with diminished weight to meet the developments of higher speeds in engineering. He thought the claims of semi-steel, in this respect, were worthy of serious consideration.

Quite a number of interesting articles had been published on this subject in the technical journals. Some writers were most eulogistic, claiming that cylinders, electrical and machinery castings were being gradually turned over to semi-steel specifications. Other writers denounced it, and maintained that equal results could be got from cast iron. He made special reference to the excellent Paper, "What is Semi-Steel,"* given by Mr. Field to the Birmingham Branch, and published in THE FOUNDRY TRADE JOURNAL.

The lecturer made it clear that the semi-steel he wished to speak about was cupola melted, with proportions of mild steel varying from 15 per cent. to 40 per cent. He intended to treat the subject not so much from the theoretical or scientific, as from the practical foundryman's point of view, considering first the advantages, and on the other hand pointing out its limitations, difficulties and disadvantages. Semi-steel did not displace steel or malleable cast iron. It was simply a high-grade cast iron, with fewer impurities and better structure. Unless cupola practice was properly regulated and controlled, the castings, while strong, were likely to be hard and difficult to machine.

Properties of Semi-Steel.

Strength.—Semi-steel was much stronger than grey cast iron as regards tensile, transverse and compression tests, toughness and resistance to shock. An example was instanced of a strong flanged bend for the bottom of a pump pipe line for a colliery. An early casting having proved defective, through inexperience of the proper gating, was struck with a heavy hammer to be broken up, but although several attempts were made, this could not be done, and the casting was kept for exhibition and trials for many months.

Physical Structure.—Semi-steel is close grained, homogeneous, free from hard spots, blow-holes and defects. The graphitic carbon is finely broken up, the phosphide eutectic small, well-distributed and frequently in well defined "mesh" formation.

Machining Qualities.—It machines easily, taking a fine polish; two striking characteristics are its faculty for taking a clean-cut screw-thread, and a clear and clean punch mark.

Resistance to Wear.—Owing to the formation of the graphitic carbon, along with the close grain and high tensile strength, semi-steel was very satisfactory for such castings as cylinders, pistons, gear wheels. McLain claimed that it was a self-lubricating metal, and from general experience it has been found an excellent metal for the castings mentioned and others.

Equal fusibility and fluidity to cast iron could be obtained, and the claim is made that it is superior to cast iron as regards resistance to heat, *i.e.*, for fire-bars, and also for many electrical purposes.

Aerial Bomb Manufacture.

His firm's experience, in the first place, was on aerial bombs. They had altered a cupola on the lines laid down by McLain, when they were asked to submit samples. These proved satisfactory, and they were soon under full swing turning out semi-steel on a large scale for a year. At one time 1,400 bombs of one particular pattern were produced daily.

Semi-steel was found to be extremely useful for certain types of munitions. It was used by the States, France and Germany long before our Government considered the material. America, towards the end of the war, had arranged a tremendous output of about 30,000,000 semi-steel shells, and there was no doubt that had the war lasted some months longer, semi-steel would have displaced steel in many cases. Experiments were carried out for some of the larger bombs, and the trials were very satisfactory, particularly in regard to fragmentation. His first contract was taken in the expectation that there would be trouble in maintaining the minimum tensile test of 14 tons, but the results of the tests were surprising. The firm submitted over 400 test bars which were pulled by officials at Glasgow University. The first failure was bar No. 140, the second in the same week. On investigation it transpired that the foreman had changed the moulder, and when the bars were made by the original moulder, who understood the importance of care and correct gating, no other failure was recorded until after the Armistice. The bars in question were cast $\frac{5}{8}$ in. dia. by 5 in. long. This admittedly was a small bar, and gave better results than the usual bar of larger diameter. He knew that this was a vexed question, but submitted that the $\frac{5}{8}$-in. bar was a fair test for castings under $\frac{3}{4}$ in. thick. The average tensile test from these 400 bars was over 18 tons. Their record bar was 21.9 tons, but higher results had been obtained by friends in England and in Glasgow, where a mixture of 50 per cent. hematite, 40 per cent. steel, and 10 per cent. scrap yielded 22.5 tons.

Low Phosphorus Necessary.

In 1918 ironfounders found it very difficult to obtain pig-iron of good quality and consistent analysis. Hematite was not available, and such pig-irons as could be obtained had to be used. The Scotch brands gave satisfactory results, and yielded good hot fluid metal. Cleveland iron was tried, but owing to its high phosphorus castings were apt to be brittle. He was a firm believer in keeping phosphorus low in semi-steel. The average analysis of about a dozen bombs resulted:—

Silicon 2.10, graphitic carbon 2.55, combined carbon 0.5, sulphur 0.065, phosphorus, 0.587, and manganese 0.65 per cent.

In this analysis the total carbon was low, and the sulphur and phosphorus within safe limits. Probably greater tensile strength would have been obtained had the silicon been lower, with the combined carbon and manganese higher.

In the physical structure was revealed the secret of the greater strength and improved properties of semi-steel. The lecturer emphasised the benefit of frequent microscopic examinations to ensure the best results being maintained. Chemical analysis was useful in itself, but must be taken into consideration with the physical structure.

In closing the case for semi-steel, the lecturer claimed for this material that founders could take the pig-irons and scrap in every day use, and by judicious mixing produce a high-class, strong, close-grained metal capable of transverse and tensile results, that could only be otherwise obtained by using cold-blast, or other special and expensive pig-irons.

Difficulties and Disadvantages.

Considerably more care and supervision was essential. In the experimental stages a good many failures occurred. This meant extra work, which was generally passed on to the foreman, and explained the reluctance of many to persevere.

It was essential to have cupola practice right, particularly in regard to correct supply of air.

His first attempts resulted in very dull metal due to volume of air being too high. There were difficulties with bad scrap and unsuitable coke. Special attention had to be given to correct gating and quick pouring. One special feature about semi-steel was, that it froze or set at a higher tempera-

* See Vol. 23, No. 237.

ture than cast iron. This made it unsuitable for thin castings of large area.

Attention was called to a series of test-bars which had been poured from the same ladle with intervals of 2½ minutes. Deterioration in the later pourings was obvious. Trouble due to this was experienced in the early stages, and proved very difficult to trace. Eventually it was discovered that one or two moulders at the far end of the shop were holding up the metal. When this was remedied the trouble disappeared.

Another disadvantage was that to ensure the very best results he had to admit, after a good deal of experience, that semi-steel had to be handled on a fairly large scale. When only one or two charges were required, semi-steel could be produced from a cupola using ordinary iron, but he had never obtained such good results or such good metal as when semi-steel was melted on the larger scale.

Cupola Practice

There was no subject on which foundrymen had such varied opinions and practice as the cupola.

Each cupola should be studied in itself. It was worth persevering until it yielded its proper quantity of good, hot metal, and was clean at the end of the day's work. To begin with, his firm lined a 54-in. cupola to 40 in. The bed was lowered and tuyeres remodelled to ensure a soft blast. This particular cupola worked well from the very beginning. He had a feeling that for semi-steel a small cupola from 36 in. to 42 in. dia. was the easiest to control, and within these limits the air could be forced to the centre by comparatively little pressure. His experience was that one row of tuyeres was quite satisfactory, and gave considerable economy in consumption of coke. Much more attention was being given to cupola practice to-day, especially with regard to the high-blast fetish so popular with our forefathers.

In summarising cupola practice the lecturer said that air should enter by volume not pressure: he recommended a large tuyere area, and emphasised the importance of measuring all charges, coke, metal and especially air. For the latter, air-blast meters were easily obtained and adjusted. For light repetition work he recommended small charges evenly distributed.

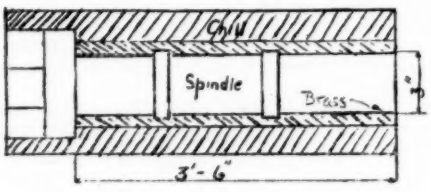
In conclusion he warned his audience to use suitable and clean scrap, avoiding small and often dirty punchings under 1 in. dia. They need not be afraid to use the scrap in fairly large pieces, but should never use turnings or borings.

The sand should be used as dry as possible, and care taken to avoid a too liberal use of the "swab."

Samples of semi-steel were exhibited, showing fracture, machining, polish and thread obtained, also the malleability obtained by moderate annealing. Slides were also shown showing general structure, particularly as regards grain, small graphite, and mesh work formation of the phosphide eutectic and also causes of blow-holes and defects.

Foundry Queries.

22b.—I have a brass sleeve to cast on a steel spindle, the approximate length of which is 3 ft. 6 in., as illustrated. I have cast two with no



result, and should be pleased if you could suggest a method by which I may succeed.—"LAITON."

22c.—I shall be very pleased if some of your readers will give me an answer to the following query: What is the best foundry practice in making ordinary railway chairs, about ½ cwt. each chair? We want to install the best labour-saving methods for repetition work.—"I. B. F.," Member, Birmingham Branch.

Book Reviews.

"THE FAILURE OF METALS UNDER INTERNAL AND PROLONGED STRESS," being a general discussion on this subject by the leading scientific and technical societies of Great Britain. Edited by F. S. Spiers, O.B.E., B.Sc. Published by The Faraday Society, 10, Essex Street, London, W.C.2. Price 10s. 6d. net.

The importance of this subject cannot be overestimated, for it is on the ability of metals to withstand continuously internal stresses that engineering is based, and our very lives depend. Since the meeting, to which this book has reference, was held three outstanding disasters have occurred, which are possibly, or even probably, attributable to failures of this nature. The three which we have in mind are the R34 airship collapse and locomotive explosions at Buxton and on the Southend line. The book under review embodies the ideas and theories of some of the prominent scientists of this country. We advisedly use the words scientist as it is meant to include mechanical engineers, metallurgists and pure science workers. Sooner or later the foundry metallurgist will have to be just as familiar with the intercrystalline amorphous cement theory and those put forward in opposition to it as he has at the moment to be *au fait* with the iron-carbon system cooling diagram. The book is divided into four sections. The first section is Dr. Rosenhain's introduction, from which it can be inferred that the title of the book should be "The Failure of Metals under Internal and *also* Prolonged Stress," because some metals can quickly break down under internal stress in a manner analagous to the "action of externally applied stress continued over a long period." The second section takes in five papers of a general character, whilst the third includes the discussion by about two dozen leading authorities. The most enlightening portion of the discussion was contributed by Sir Alfred Ewing, who explained the slip theory due to the intercrystalline cement in the following way: ". . . the amorphous boundary is not a single layer of atoms, but is made up of many layers. You have to penetrate some little way before you find the space lattice of the atom within it. You have to go a little way into the other crystal before you find its normal space lattice, and between the two you will probably have a jumble . . .—not a system, because . . . it is quite unsystematic of atoms where there is no definite space lattice and where therefore slipping is not possible. The material in that region may be described as a super-cooled liquid. It is more susceptible to temperature than the properly cemented parts of the crystal, and in it the time effect of stress is particularly important. When you have a thing which is particularly a viscous fluid you must expect to find the effects of stress which are not found in the normal crystal, and that is exactly what . . . you do get in the intercrystalline cement."

Section IV. is divided into two sub-sections, A and B. The former contains seven papers on steel and the latter four on brass, together with the discussions. Though the whole subject is very extensively dealt with and much of practical utility is given, there still is not, and probably never will be, a remedy which will be equally applicable to all types of metals, but there is every reason to believe that existing and further experience will disclose methods which will overcome these troubles in the near future. No technical library can afford to be without a copy of this symposium.

British Chamber of Commerce in Paris.—In his speech at the 48th annual general meeting of the British Chamber of Commerce in Paris last week, Sir Thomas Barclay (President) dwelt especially on the immediate necessity for a reduction in the exorbitant customs rates. In expressing the view that the most critical stages of the severe commercial crisis had passed, he declared that the Chamber had been busier than ever during the past year. Special reference was made to the *modus vivendi* signed between France and Canada on January 1, 1921. The arrangement gave but slight satisfaction to French and Canadian traders, and the Chamber had not yet ceased to urge upon the Canadian Government the necessity for a permanent trade convention. A large number of representatives of Canadian firms had visited France during the year.

Sand Blasting.*

By E. L. Samson.

(*Continued from Page* 118.)

It will be readily recognised that the use of such tables must, unfortunately, be limited, as the size of castings may frequently prevent the installation of such plant, as otherwise the tables would become too cumbersome or the cabinet too high. On the other hand, where sufficient quantities of large and small castings have to be dealt with

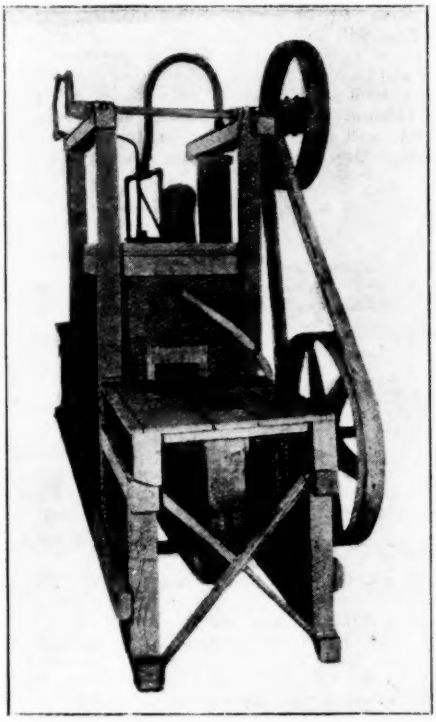


FIG. 13.—HORIZONTAL SAND CONVEYOR.

such an installation is ideal for the latter, while for the larger castings a sand-blast room would have to be adopted.

Sand-Blast Conveyors.

As the name implies, transporters or conveyors are used to bring the material to a sand-blast cabinet, fitted with automatically-driven nozzle carriages, which allow of vertical or horizontal adjustment of the sand-blast nozzles. These appliances are only in their infancy, and constant improvements are being effected. It is the ideal machine for blasting plates, springs and tools. The conveyor may be horizontal, as shown in

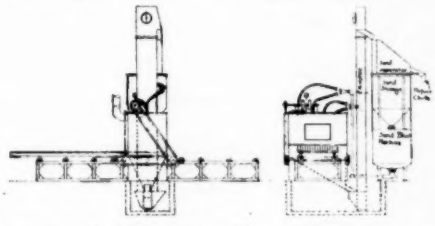


FIG. 14.—A SAND-BLAST CLEANING TABLE OF THE LONGITUDINAL TRAVEL TYPE.

Figs. 13 and 14, or vertical. In fact, the appliance is always designed to meet special conditions. Thus, for instance, an equipment might have nine or more nozzles, of which some are cut out if a narrower piece than the widest provided for is to be blasted. The equipment is practically automatic; the results achieved are astounding, as only labourers would be employed to bring the goods to the conveyor or take them off, while one competent man would supervise the blasting operation, that is, he would have the materials put through once more if the cleaning operation is not completed.

Fig. 15 shows a combination of a sand-blast room with table and a cabinet, and Fig. 16 shows a sand-blast room with work bench for small castings, and a dust-collecting arrangement, which exhaust from the bench direct.

Dust Collecting.

This is really the greatest problem in connection with any sand- or shot-blast plant, and most plants used in this country utterly fail in making suitable provision for dust collection. To send

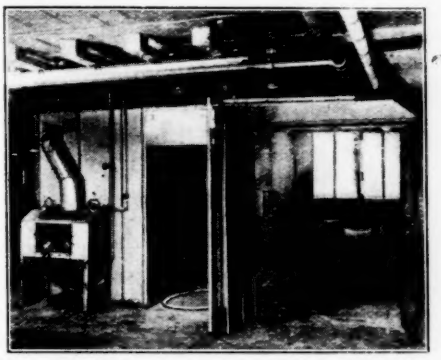


FIG. 15.—COMBINATION SAND-BLAST ROOM AND CABINET.

fresh air to the operator through piping in the helmet gives some assistance, but surely something should be done to improve the lot of the sand-blast operator, whatever the cost may be. Cyclone dust arrestors are mostly very inefficient, and if, as in the case of British plants the same exhauster is used to raise the abrasive material and the dust, the cost of the necessary power together with the upkeep of the fan-blades is very high.

The problem of dust-collecting is by no means solved, but great improvements can be made by introducing a separate dust-collecting unit in connection with the sand-blast machine, instead of using the exhaust fan for lifting the abrasive as well as the dust produced. There are various methods of dealing with the question, and

FIG. 16.—SAND-BLAST ROOM WITH WORK BENCH FOR SMALL CASTINGS AND DUST COLLECTING ARRANGEMENT.

Fig. 17 shows an appliance which is called a turbine dust arrestor, and for which Patents are pending. From the outside it looks like a cyclone dust arrestor, but the interior shows a special construction of circular baffles, which greatly contribute towards the collection of the dust. In fact, an efficiency of about 85 per cent. is attained, *i.e.*, only 15 per cent. of the dust particles are drawn into the fan from where they are blown out into the atmosphere, or are dealt with as desired.

* Paper read before the Institution of British Foundrymen (London Branch), December 9, 1921

The dust collected in the dust arrestor drops out of the bottom through a gate, and can either be collected in sacks or flushed away. This unit can be placed wherever convenient between the sand-blast equipment and the exhaust fan. As will be seen from the illustration, the dust piping is connected up at (R), while at the top is the pipe line connection to the fan. This type of arrestor can be used either on suction or pressure. It is comparatively cheap, but there must be many instances where the problem of dealing with the 15 per cent. of dust may become a pertinent one.

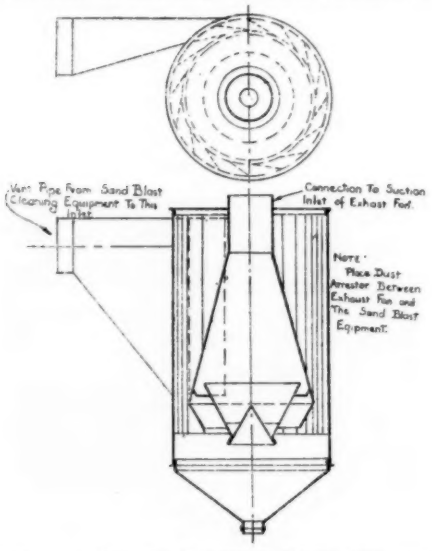

Vent Pipe From Sand Blast Cleaning Equipment To This Inlet
Connection To Suction Inlet of Exhaust Fan.
Note:- Place Dust Arrestor Between Exhaust Fan and The Sand Blast Equipment.

FIG. 17.—DOELCAM RAREFIED DUST COLLECTOR.

The next step was to design a dust-collecting unit, Fig. 18, consisting of a system of cloth screens, which is termed a screen-type dust-arrestor. This is a steel housing in which a number of cloth screens are arranged, these, on the average, having an area of about 50 sq. ft. The size of the housing and the number of screens to be used naturally depend upon the volume of air and dust that have to be dealt with from the sand-blasting machine. These cloth screens are fastened to frames which are wide at the top and taper at the bottom; in other words, they are wedge shaped. They are pivoted at the top, but hang loose at the bottom. The reason for this is that means must be provided to easily jar off, or knock off, the dust that settles in the cloth. Specially simple jarring mechanism is provided for at the outside of the housing, and this consists of a number of hammers worked by a crank, which tap against the housing and successfully clear the

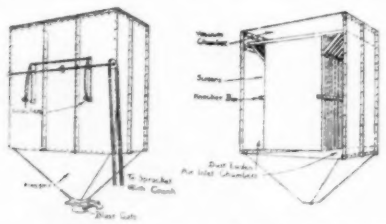


FIG. 18.—A DOELCAM SCREEN TYPE DUST ARRESTOR.

pores of the cloth if the operation is effected two or three times a day. All the dust collected in the pores then drops off into a hopper at the bottom of the housing, from where it can be flushed away.

This is a very efficient unit which can be placed at any available spot between the sand-blasting equipment and the exhaust system. It gives an efficiency of nearly 100 per cent., *i.e.*, all the dust is collected. The only drawback with this unit is that working under a partial vacuum the power consumed is comparatively high, though otherwise comparing very favourably with the practice in this country previously explained.

The ideal system is shown in Fig. 19. This is really a combination of the turbine dust arrestor and the screen type dust arrestor, utilising the advantages of both. The turbine dust arrestor will not take out all the dust, the screen-type dust-arrestor, working under partial vacuum system, the loss of power and its consequent efficiency is fairly low, yet if, for instance, the screen type dust arrestor were used so that the dust is pressed through same instead of drawn, the result would be the rapid wear of the fan wheel and congestion of the arrestor. If the two machines are combined—and this is termed the double grip system—the dust-laden atmosphere may be sent through the turbine arrestor by suction, taking out all the heavy particles, while the finer dust is pressed through the screen type arrestor, the same fan, of course, being utilised. Thus all the dust will be collected, and there is an increase of power efficiency of at least 40 per cent.

It will be clear that in the turbine dust arrestor, where baffles or pockets are placed all around the circumference, a suction is created in each pocket, and the heavy dust is drawn into same, collected and then falls into the hopper. The

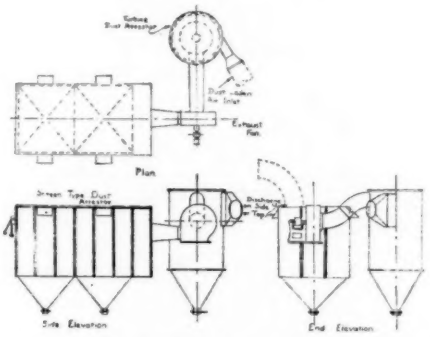


FIG. 19.—A DOUBLE GRIP DUST COLLECTING SYSTEM.

speed of the air being considerably reduced, say, to less than 500 ft. per min., the heavy dust is easily collected, and the remaining 10 to 15 per cent. only has to pass through the exhaust fan, and, this being very fine material, the wear and tear on the propellor blade is not so heavy.

The question of cost has to be contended with, but a time will come when the sanitary and humane side of sand-blasting equipment will receive the keener attention of the Factory Inspector, and this Paper has shown in what directions improvements can be made.

To sum up, all castings should be sand-blasted, after coring, before final chipping, fettling and grinding operations. Special dust collecting chambers of ample size and with proportioned capacity fans should be insisted on to avoid dust nuisance.

The presence of the operator in the blast chamber proper should be and can be avoided, except where large castings have to be sand-blasted.

High-pressure air is more efficient and less costly in operation than low-pressure for sand- or shot blasting.

Elevated, Midway and Subway Gating for Castings.*

The author's object is to show that it is often quicker to ram up a three-part box for the multiple production of similar simple castings than a two-part box. Less box-area is used in gates and leads, and, in fact, the two lower sections can be entirely devoted to castings; also wasters can be reduced from 25-30 per cent. to 2-3 per cent. He describes various ways in which this may be done satisfactorily for a particular type of pattern on plate, whether gated at top, bottom, or middle; a lay-out of the pattern-plate for a more usual, obvious, and unsatisfactory method is also shown. He states that the method is not suited to snap flask moulding, and cannot be universally applied to simple repetition castings. The method is discussed in relation to cast iron and non-ferrous metals, and is recommended for pressure work.—W. H. PARRY. ("Am. Mach." 55, 209.)

* Institution of Civil Engineers Abstract.

Institution of British Foundrymen.

THE BASIC HEARTH ELECTRIC FURNACE AND SOME PROBLEMS OF CAST IRON.

Mr. George K. Elliott's Reply to the Blackpool Discussion.

Mr. Elliott wrote that in the following paragraphs he would record a few remarks based upon the discussion of his Paper as transmitted to him in the September 22, 1921, issue of THE FOUNDRY TRADE JOURNAL. The various discussions will be treated in the same sequence as shown in the journal.

Hot Metal.

MR. RIDDELL'S opening discussion reveals a close observer, an experienced operator of the cupola furnace, and an original thinker. There is considerable so-called pure theory that can readily be made to support his views concerning the effect of combined carbon in the charge upon the final temperature of the cupola melt, and his device of wetting the coke is highly ingenious. He was inclined to favour Mr. Riddell's views, but had not always been able to prove them in practice. Supporting his theory he had long noticed that steel scrap in the cupola charge generally produces metal hotter than usual. On the other hand, under the cupola practice in one foundry, he had not been able to demonstrate that machine-cast pig-iron, presumably high in combined carbon, gives any colder iron than does sand-cast pig, which is comparatively low in combined carbon.

Table of Strengths Represent Normal Practice.

In reference to the remarks of Mr. J. R. Hyde, he admitted that it is to be regretted that it was not possible to include pouring temperatures in the table of transverse test results, and were the Paper intended to be more scientific than it was the lack would be unpardonable. However, the Paper was written in order to record some observed facts, and perhaps some fancies too, all of which had conception under everyday working conditions. The results in the table were taken at random from daily test reports, and were not any part of an organised scientific investigation. The process was instituted and developed during the war period, when there was no time for such investigation as long as it worked and delivered the goods. However, the method of pouring the bars is firmly standardised in the plant where made, the iron passing through one 1-ton and one 40-lb. hand-ladle before entering the mould. The temperature at the cupola deviates very little from 1,450 deg. C. Knowing as we do the average loss in each transfer of the metal we can make the very fair guess that the bars all were cast very close to 1,350 deg. No attempt was made to cast these bars at a high superheat, and all his remarks concerning the advantages of high-temperature cast iron are to be construed in connection with commercial castings and not with test-bars. Continuing further, Mr. Hyde makes a lengthy reference to the table of strengths. In doing this he has misunderstood the only purpose of the table, which was not to exhibit phenomenal records (indeed, this was purposely avoided) but rather to illustrate the improvement that can be wrought in commonplace irons by the proper treatment in the electric furnace; it is merely a "before" and "after" exhibit. Also he believed that Mr. Hyde would agree with him that the interpretation of the results of one size and shape of bar in terms of a far different bar, probably made under far different moulding conditions, is usually a very futile thing, and any deductions and inferences made therefrom are not to be taken over seriously. However, in order to aid in a just estimate of the irons in question, he drew attention to the standard specifications of grey-iron castings as prescribed by the American Society for Testing Materials, which call for the following minimum breaking loads on the described arbitration bar:—

Castings having any section less than ½ in. thick, 2,500 lbs. (22.3 cwt.).

Castings having no section less than 2 in. thick, 3,300 lbs. (29.5 cwt.).

Castings not included in preceding two classes, 2,900 lbs. (25.9 cwt.).

Viewed in the light of these specifications the irons in the table all were improved by the electric-furnace treatment enough to enable them to pass the specifications for the next higher class.

Good Cupola Practice Reduces Duplexing Time.

MR. V. C. FAULKNER asked about the cost of the electric furnace for iron castings, and he had nothing to add to Mr. Robertson's capable reply, unless it be that even in the United States this item varies within wide limits depending upon many conditions, such as the source of the current, the amount of refining needed, and the degree of superheat. Cupola practice figures here, for the electric furnace places a material premium upon good practice, because the best product of a perfectly-operating cupola generally requires the least time in the electric furnace.

The Sulphur Problem.

MR. H. J. YOUNG injects much substantial matter of a concrete nature into his interesting discussion. He would be the very last one to attempt to woo him or any other good foundryman from the free use of the cupola for the general run of castings, in which field, as he had declared before, it is without rival. His Paper was intended to be very emphatic upon this point. Mr. Young's data concerning sulphur are valuable, but it is to be regretted that the harmlessness of sulphur is not proved by something more convincing than the results obtained in test-bars. Our knowledge of cast iron will be greatly enriched when tests of a more dynamic nature than the customary transverse and tensile test are more widely adopted. From observations that he had made of the effect of water-hammer upon certain high-sulphur iron castings he was led to believe that such iron does not show up so well under shock as under the more common tests. Quite frequently test bars are not as just a criterion of cast iron as we should like to believe, and always it is best to examine the castings themselves. He had first-hand knowledge of castings that cannot consistently be made sound throughout when the sulphur runs over 0.10 per cent. That for many classes of work the sulphur limits as given in the Paper are too low he was willing to grant, but that segregation of sulphide is liable to set in when they are exceeded he was unwilling to gainsay. Whether the segregation be harmful is quite another question, the answer to which depends upon the nature of the castings; very often it is not.

However, the question of sulphur is of the utmost importance, containing many unknown factors, and only by discussion such as this of Mr. Young's will full light eventually be gained. Continuing his discussion, Mr. Young repeats the mistake of several others in taking it that the table of tests was displayed as something phenomenal in the way of strength. That these results frequently are beaten in the cupola, as far as test bars are concerned, he himself knew from a multitude of personal experiences, but also he could aver that for very many kinds of castings, if indeed not for all, the electric furnace can show a marked superiority in the castings themselves. The chief ways in which this is apparent are in uniform soundness, freedom from slag, oxides and other non-metallic inclusions, and a minimum of cold-shuts. In studying Heat 3,419, Mr. Young is puzzled that phosphorus and carbon are not reduced to corresponding degrees by steel additions while manganese was increased. The carbon was higher than expected because some was dissolved by the bath from the slag, and the manganese pick-up probably came from a manganese-bearing basic open-hearth slag that was used on this heat in place of making up a new slag, coupled with the possibility that the analysts may have been slightly in error in one or other of the determinations. He disagreed with Mr. Young when he said that the elimination of sulphur is not a good thing; he had seen too many castings improved by a change from high to lower sulphur. Possibly Mr. Young had in mind a particular class of castings in which his statement holds good, but as a broad generality it certainly calls for emphatic disagreement. Cast iron is such by virtue of its free carbon and not through any

other non-metallic inclusions such as sulphide of manganese. The presence of this last has been largely inevitable under the old prevailing conditions, but it is by no means necessary to cast iron. The best argument against excessive sulphur is that it is a non-metallic inclusion that breaks up the structure of a casting. That generally satisfactory iron castings are made with comparatively high sulphur does not prove that sulphur is a benefit or that such castings would not be better were the sulphur lower.

A Definite Improvement through Duplexing.

In his written contribution MR. J. SHAW, who, by the way, is to be warmly congratulated for his Paper entitled "Some Perplexing Foundry Problems," puts several pointed questions. In answer to the first, he believed that many of the advantages gained from low-grade material put through the duplexing process can be largely, if not wholly, realised by a better selection of material and better cupola practice. However, not always and everywhere is the needed better material at hand; this is especially true in some parts of the United States that are remote from the best sources of supply. As to the next question, he had the opinion that at present very rarely is there sufficient market to support an exclusively duplex plant; generally only a selected part of the cupola melt would be put through the electric furnace. Mr. Shaw is entirely correct in surmising that the increase in strength is not all accounted for by the reduction in sulphur, because changes in carbon and silicon and high-casting temperature all have contributed to the results, which is as he had implied in the Paper. Mr. Shaw and Mr. Cook both express surprise at the low total carbon in heat 8,182 as it came from the cupola. This is readily accounted for by the fact that the charge contained over 50 per cent. rusted steel scrap and the remainder a rust-eaten lot of light cast-iron scrap, the whole being as unpromising a lot of metal as one could well imagine. So sluggish and over-oxidised was the iron as it flowed from the cupola that not even the test bars could be cast with it. This heat emphasises very well one of the main points of the Paper, *i.e.*, that the duplexing process possesses a noteworthy ability to make worthwhile material from that which is mediocre or worse.

Oxygen-Bearing Irons are Hard.

MR. J. E. HURST asked whether he (the author) was in the habit of reducing the amount of bed coke in the duplex process. If there is meant the height of the bed charge it can be answered that no reduction is made; this is simply because he did not favour anything that savours of a let-up in what seems to be the best practice, even though the electric furnace has a powerful tendency to correct many of the deficiencies of careless cupola practice. It always had been his opinion that a too low bed influences strongly toward oxidised, cold iron. Colder iron charged into the electric furnace means simply longer time and more current to attain the desired degree of superheat. Concerning the strengthening effect of oxygen upon cast iron, Mr. Hurst asks the evidence that this is brought about by assisting in the retention of carbon in the combined condition. To him it seemed that this theory is fairly well supported by the observed fact that oxygen-bearing irons generally are harder than similar irons that lack the excess of oxygen.

More about Sulphur.

MR. F. J. COOK brought up the question of sulphur, and reiterated the opinion that good strength is obtainable with this element present in greater quantity than seemed sanctioned in the Paper. Again he presumed that test-bar strength was meant. This was one thing, but composite strength in all the sections of complex casting was quite another thing, and often had he seen castings of good test-bar strength be actually very poor, due to the segregation and other changes brought about by the comparatively slow cooling of the whole. To illustrate he had in mind some hydraulic castings that had to withstand without show of porosity a pressure of 500 lbs. to the square inch. With cupola metal the average rejection of these was about 30 per cent., which was reduced to practically *nil* when a change was made to the low-sulphur, deoxidised, superheated product of the duplex process. Also there is the case of a pipe-shape casting with a bell at one end that invariably "came bad" whenever the sulphur ran over 0.10 per cent., and that finally was made most economically by the duplex process. In both these cases the change to duplexed iron was a success in a practical sense, while measured by comparative test bars the benefit would have been almost negligible.

Nitrogen in Cast Iron.

MR. E. ADAMSON inquired how the temperature value of 2,200 deg. C. was obtained. This was obtained from page 103 of Dr. Moldenke's "Principles of Iron Founding." He was not in position to verify the temperature, but probably it is one of the results of the extensive pyrometer investigations of the cupola made by that authority several years ago. Perhaps there are grounds for Mr. Adamson questioning in a mild way the presence of nitrogen in steel and cast iron, but the most recent investigations seem to establish beyond doubt that nitrogen is not too inert to unite with iron at elevated temperatures, from which it may be reasoned that conditions may occur in the cupola or other melting furnace under which at least a small amount of the element can be picked up by iron. He mentioned nitrogen in his Paper, because it had been found in the quantities given by a very reliable laboratory that was entirely familiar with the determination. This question of nitrogen in iron merely takes us into one of those unexplored regions concerning which there is always a certain delightful temptation to indulge in speculation. He was inclined to the belief that conditions may arise in the electric furnace under which there would be an absorption of nitrogen making such electric furnace iron show more nitrogen content than the average cupola product. Mr. Adamson had asked several more interesting questions which Mr. Robertson has answered so well that he found no need of attempting a reply. In concluding Mr. Adamson brings up a point regarding the sequence of the oxidation of silicon and carbon. It seems probable that some of the silicon is oxidised before or along with the carbon, but at the prevailing high temperature of the electric furnace the silicon is reduced by the carbon in the bath and so finds its way back into the metal.

Conclusion.

In closing this discussion he wished heartily to thank Mr. Robertson for the very considerable part he played in handling the Paper, and to compliment him in the highest terms for the able manner in which he filled the precarious rôle of replying to the discussion of another person's paper. So well had he done this that he really had found himself relieved of the task of replying to a very considerable portion of the discussion.

SHEFFIELD BRANCH.

ANNUAL DINNER.

The annual dinner was held at the King's Head Hotel, Sheffield, on January 27, and was very successful. Mr. John Watson (Branch-President) occupied the chair, and there was an attendance of about 100, including the Lord Mayor of Sheffield (Ald. C. Simpson), the Mayor of Rotherham (Ald. K. W. Fieldsend), the President of the Institution (Mr. Oliver Stubbs, M.I.Mech.E.), Mr. H. Cole Estep (American Foundrymen's Association), Professor C. H. Desch (Dean of the Faculty of Metallurgy at the University of Sheffield), and Mr. W. F. Beardshaw (past-president of the Sheffield Chamber of Commerce).

American Trade Pre-eminently Important.

"The City and Commerce of Sheffield" was proposed by MR. H. COLE ESTEP, who spoke principally on the factors required for a trade revival. He agreed that it was desirable that there should be a re-opening of the Russian and Eastern European markets, but did not consider that this was essential to a restoration of trade. What was needed, in his opinion, was a restoration of confidence between the great commercial nations of the world—including Great Britain and America—which had buying power to-day, and not next year or the year after. He supported this argument by figures showing how greatly our exports

to America exceeded those to Russia, both before the war and during the past year. The British peoples had the ability to build up a real prosperity and a real re-establishment of business, in which the commerce and industry of Sheffield would most certainly and inevitably be pre-eminent.

THE LORD MAYOR OF SHEFFIELD replied.

"The Visitors" was proposed in a happy speech by the BRANCH-PRESIDENT, and acknowledged by the MAYOR OF ROTHERHAM.

Technical Societies Make for Progress.

PROFESSOR DESCH, in proposing "Kindred Associations," said one great distinction of those technical societies, perhaps marking them out from all other organisations in industry, was that their objects were mainly unselfish. The members met together for the purpose of exchanging information, essentially for helping one another. The aim of a technical society was not a selfish one. It was to advance the industry as a whole, and not the interests of a particular individual. As the members met together and exchanged ideas they knew that in doing so they might be benefiting a competitor, but at the same time they knew that the industry as a whole, which meant society as a whole, was benefiting. Those industries had shown themselves most progressive where these societies had been most flourishing, and the exchange of opinion had been most free. Those industries which rigidly preserved their trade secrets were generally the backward industries, and the trade secrets which were most rigidly preserved were the secrets which had very little value. The most important advances in industry, and he thought particularly in metallurgical industry, soon became common property, and that was to the general benefit of the workers in the industry and the trade concerned. The Institution of British Foundrymen had served that purpose particularly well. It drew its membership from a very wide circle, including employers and employed, and he had found not only in the Sheffield Branch, but in the Scottish Branch, with which he was associated for some years, that the members were always particularly willing to help in the matter of information. They who stood somewhat outside the industry, whose interests were scientific and whose connection with the industry was only indirect, appreciated that very highly. They greatly appreciated being able to go to those societies, to be able to ask for information on practical points, and sometimes, perhaps, to be able to help a little by contributing some scientific information.

Inception of Foundry Classes in Sheffield.

Dr. Desch mentioned that the University of Sheffield was going to make an effort to meet the requirements of the foundry industry. This term, for the first time, it was giving a course of lectures for foundrymen. They had been fortunate in securing the co-operation of two gentlemen who were outside the University, although old students —Dr. Longmuir and Dr. Hatfield. He hoped that employers would do their best to encourage their men to attend. The classes were an experiment this year, but if they were successful they would, he hoped, be followed up by further developments in future years, until they had a thoroughly good system of foundry education established at the University. The lectures were intended for workmen, which meant that the language used would be simple. They would not go too much into molecular theory, and would not use any very formidable terms. As far as possible the lectures would be given in the simplest of language.

The Collection of Scientific Data.

DR. T. BAKER (representing the Sheffield Association of Metallurgists and Metallurgical Chemists) replied. He said there were one or two points which all societies had in common. One of these related to the supply of papers. Members were not keen in coming forward and placing their experiences on record. If this was not done he did not see how a society was going to progress. They must bring their difficulties to their society and discuss them in common; then they could not help but gather information which would very often solve their problems, and, at the same time, they would be helping the industry along. Every society had two classes of members, the givers and the getters. Once the getters became the majority then the society would go down. He thought societies might do more useful work than they were doing in accumulating and cataloguing information of the particular industries in which they were engaged. If it was all collected and stored in a readily accessible way it could not help but be of the utmost value to the pure scientist and the applied scientist alike. Every society and industry had its own special problems, which were peculiar to that industry, and might be peculiar to a particular district, and if the society there did not collect the information it might never be collected, but would have to be rediscovered generation after generation instead of being readily available. The speaker touched on the importance of continued education. A man's knowledge got out of date, and therefore all societies must be educational. He thought every society would do well to include among its papers every session one or two of what might be called the tutorial kind, dealing with the fundamentals of the science or the applied science which was peculiar to that industry, thus doing a little teaching for the benefit of those members who had ceased their schooldays before information was so readily available as it was to-day.

Co-operation Necessary.

MR. W. F. BEARDSHAW, in proposing "Institution of British Foundrymen," said the motto of the Institution was "Science hand in hand with labour." He said the working of Capital and Labour hand in hand was a most important matter. For some years he had been meeting Labour leaders, and had found them a very sane lot of men indeed. Employers were perhaps in a strong position to-day, and he hoped that they would be merciful, that they would work hand in hand with Labour, and that they would again see that good time which they were all looking for, and which he certainly thought they would see within the next few years. He was glad to notice that, of the Institution's total membership of 1,800, the Sheffield Branch had 220. That was a figure of which they might be proud, and he thought it might be considerably enlarged by the individual effort of the present members.

Progress of the Institution.

MR. OLIVER STUBBS, replying to the toast, said he agreed that a great deal could be done by employers and employed coming together more than they had done in the past. He thought the times now were showing that by mixing together more, and doing away with mystery between the two sides, they were certainly going to get more peaceful times. If there was one institution more than another which was doing the pioneer work in that direction he ventured to say it was the Institution of British Foundrymen. One of the factors of their success consisted of the annual social gatherings of the different Branches, when they were able to come together and spend a pleasant evening. They were to be congratulated on having been able to keep their membership and their Branches so solid, in view of the great amount of unemployment. A great many of their members were from the rank and file, and no doubt found it extremely difficult to pay their subscriptions, owing to the short time that was being worked. All credit to those men in the shops that they had responded so very nobly. He hoped that they had set an example to the employers to come in bigger numbers than ever and be subscribing members to the Institution, because, after all, the Institution was educating these men for the benefit largely of the firms who would be fortunate enough to employ them in a higher capacity than that of the ordinary artisan. He was pleased to say that Sheffield was making big strides as regarded subscribing firms. At the Council meeting at Birmingham the previous Saturday the number of members elected represented subscriptions equal to £124 per annum. The Institution was undoubtedly making big strides. They recognised that the Branches were the means of making the Institution, and that the function of the head office was simply to act as a clearing-house, and to some extent to keep the Branches in order, although he was glad to say Sheffield did not want much keeping in order. They had had some excellent secretaries, and Sheffield had a very ex-

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cellent secretary now. He did ask them in Sheffield not only to stick to their secretary, but also to support wholeheartedly their Council, and, if it was at all possible in these hard times, to endeavour to improve their Branch. They were doing excellently, but let them not be satisfied.

Trade Improving.

As regarded trade, he believed it was improving. He had heard that day of two large firms who were ordering their fuel for three months, whereas for the past eighteen months they had not ordered more than a month's supply. These were manufacturing concerns, connected directly with foundry products. There was a tremendous lot of unemployment, and a great many of the workpeople did not know how to put their time in during the day. He had offered a suggestion, which had been taken up in one or two districts, where some of the firms had opened their foundries on the days when they were not running, and the foremen and managers had got the men together and given them a short talk on educational matters concerned with the foundry. That had been a means of keeping the men off the street. He thought it was very desirable and necessary that they should try and do more for those who were not as well able to help themselves as employers were.

Time Opportune for Re-organising.

He suggested to all of them that during these quiet times they should put their foundries into proper working order for the days when the good business came. There were a great many foundries that wanted bringing up to date. One was tempted to repeat what had so often been said, that we were an unscientific people trying to live in a scientific age, and we were not making sufficient progress and not getting sufficiently up to date. The other day he was in a foundry, portions of which were lit with hand gas lamps so that the men about the shop could see where they were carrying their metal. He believed good trade would come, and the people who would benefit were the people who had the best works and the best workmen.

The Royal Charter.

Some of them might ask him what did the Royal Charter mean, that they had got as an Institution. They were all very proud that they had got that Charter, and he believed a great deal of the credit for it was due to their past-president of the Institution, Mr. T. Firth. He could tell them that it cost a lot of money to get the Charter, but he believed it was worth it. The members of the Institution were now in the same position that they would be if they belonged to the Institution of Mechanical Engineers or similar societies, and were perfectly entitled, if they wished, to use the letters "I.B.F." after their name.

Medals for Competition.

He was pleased to tell them that the Institution had now two medals which would be open for competition. Mr. Mayor, of Dumbarton, the donor of the presidential chain, had given a sum of money to provide a medal for competition between the Scottish and Newcastle Branches. He was proud to say that another society of which he had the honour to be president had made a present to the Institution of British Foundrymen of a sum of £200, the interest on which was to provide every year a medal for the most meritorious service rendered by any member of the Institution of British Foundrymen, the competition not being confined to any area. The rules were so made that they did not intend a purely scientific man to carry that medal away. If a man in a shop rendered meritorious service to the Institution he would be equally eligible. The first medal would be awarded at the Convention to be held at Birmingham in June this year.

During the evening a capital entertainment programme was carried out by members of the Branch. Four members gave a quartette, there was a song by Mr. J. A. Currie, Mr. Ambrose Firth gave a recital, and a number of humorous stories were told by Mr. J. Kent Smith. Mr. Frank Rodgers was the accompanist.

How Design Affects Foundry Costs.

By F. C. Edwards.

In reducing production costs, the line of least resistance should be diligently sought and then faithfully followed by employer and employee. Though the laws of economics are inexorable, there are other methods of satisfying their requirements besides the painful ones of cutting down wages and renouncing profits.

In this connection many substantial economies may be effected by a drastic overhauling of existing designs. Where castings are concerned, concrete results, in the way of simplifying foundry production, ensuring greater accuracy, and facilitating assembling will thus be secured. Indeed, in some cases, a complete reversal of the policy frequently met with—in which the attainment of the end seems to ignore the means—is advisable in the interests of economy, and the design subordinated to production.

The orthodox view of design seems to involve a certain sacredness which is seldom justifiable. Clearly, in engineering production, the perfection of a design lies not only in the suitability of the finished machine, or component, for its intended purpose, but also—and especially where mass production is contemplated—in the completeness with which it embodies the consideration of every step in production.

Obviously, the practical knowledge of the works should be utilised to the fullest extent to ensure the best methods. In the foundry, perhaps more than any other department, it is of the utmost importance that the projected design be kept well within the possibilities of its execution; the margin of safety should not merely be ample, it should be the maximum obtainable.

The elementary fact that moulds are usually made of sand—not of wood or metal—seems to be often overlooked. That this remark is not as superfluous as it may at first sight appear may be proved by a cursory examination of the work going through almost any foundry. It is no uncommon thing to find miniature landslides taking place on the withdrawal of the pattern which a slight alteration in design would considerably reduce or completely obviate. The writer has often marvelled at the coolness displayed by the moulder in these cases. The skill and patience exercised in building up the mould ought to be realised by the delinquent who is the cause of the trouble—whether he be draughtsman or patternmaker.

In designing castings, the withdrawal of the pattern from the mould must be kept constantly in mind, and the greatest permissible amount of taper should be shown on the drawing. Generosity here doubly pays—the firm and the workman. "How much taper ought to be allowed?" is a question often asked. The foundry echoes: "Taper without stint; you cannot give us too much." Although this matter is usually left to the discretion of the patternmaker, the writer advocates the adoption of the principle to an extent involving radical alteration in design which, of course, is quite outside the province of the pattern-shop.

A design that renders necessary a multiplicity of loose pieces on the pattern certainly possesses little beauty from the foundry point of view. Loose pieces may get displaced, lost, or, worse still, left in the mould. Dee-shape fixed facings, for instance, are always preferable to loose washers wherever they can be conveniently substituted. Chipping strips, etc., should run with the line of pattern withdrawal instead of at right angles to it; they may then be affixed to the pattern.

Imperfect design, again, is responsible for much trouble and scrap arising from contraction strains. The important fact to take into considertion here is that equal cooling (*i.e.*, equal contiguous masses of metal) means equal contraction; and, by implication, an absence of initial strains set up during cooling. In pulleys, etc., S-shape arms are infinitely preferable to straight ones. In this case the strains are nullified or adjusted by a slight alteration in the shape of the arms.

Finally, complicated cases are, perhaps, best dealt with by a small research committee composed of the chief designer and the managers respectively of the pattern-shop, foundry, and engineering departments.

Trade Talk.

THE WORKS of the Sheffield Simplex Motor Works, Limited, have been closed.

TWO MORE furnaces are re-starting at the Duffryn Steelworks, Morriston, this week.

STUDEBAKER, LIMITED, have acquired the works of the British Ensign Motors, Limited, Willesden.

THE BEDE METAL WORKS, Hebburn, resumed on February 8, after being closed for some months.

JOHN G. KINCAID & COMPANY, LIMITED, engineers, of Greenock, are to close down their works at an early date.

HYATT, LIMITED, have removed from Thurloe Place, South Kensington, London, S.W.7, to 56, Victoria Street, London, S.W.1.

MR. A. LEVY, scrap merchant, 4, College Street, Swansea, has opened an office at 38, Great James Street, Bedford Row, London, W.C.1.

IT IS AUTHORITATIVELY ANNOUNCED that H.R.H. the Duke of York will visit the International Foundry Trades Exhibition at Birmingham on Tuesday, June 20.

EXTENSIONS are to be carried out shortly at the Roath Power Station, the new plant including three water tube boilers, mechanical stokers, coal handling plant, economisers, etc.

JOHN JAMES SMITHIES, LIMITED, Baron Street and Livsey Street, Rochdale, have acquired the business of Jas. Marshall, iron and steel merchant, etc., 19, Oldham Road, Rochdale.

THE paper on the "Combined Internal Combustion and Compressed Air Engine," to be read before the Institute of Marine Engineers, has been postponed to Tuesday, February 28.

A FURTHER delivery of locomotives has recently been made by Armstrong, Whitworth to the Belgian Government; 13 engines and one tender having arrived. Reception tests are still in progress.

THE STANTON IRONWORKS COMPANY, LIMITED, have decided to completely close down the Alfreton ironworks for at least three months. The furnaces have been damped down since the coal strike.

"STAINLESS STEEL" was the subject of a lecture given by Mr. J. H. Monypenny (Sheffield) on Saturday last to the members of the Keighley Association of Engineers. Mr. J. McNish presided.

A MEETING OF IRONFOUNDERS representing the Cardiff, Newport and Gloucester ironfounding industry was held at Cardiff, Mr. L. Gould presiding, when the scheme of the British Cast Iron Research Association was detailed by Mr. T. Vickers, who is also addressing a meeting at Bradford on March 4.

IT has been decided to postpone the opening of the British Empire Exhibition, at Wembley Park, which was to have taken place in 1923, to 1924. It has become evident that the project is so vast that it could not be adequately prepared by next year.

THE members of the West of Scotland Iron and Steel Institute held their fifth meeting of the twenty-ninth session in the Royal Technical College, Glasgow, last Friday, when the Paper by Mr. Joseph Jefferson on "Some Notes on Steel Castings" was read.

INTERNATIONAL COMBUSTION ENGINEERING COMPANY, LIMITED, South Place, London, E.C., inform us that they hope to start operations at their new foundry at Normanton, Derby, about June. They have bought their cupolas from Messrs. Geo. Green & Company, of Keighley. The largest has a shell diameter of 7 ft. Messrs. August's Muffle Furnace, Limited, of Halifax, are supplying the core ovens and drying stove equipment.

NO VESSELS were launched in the Tyne during the month of January, as compared with 11 vessels of an estimated net register tonnage of 28,054 in the corresponding month last year. According to the Tyne Improvement Commissioners' records, the last previous month during which no vessels were launched in the Tyne, was January, 1883.

THE DIRECTORS of Broken Hill Proprietary Company, Limited, state that owing to space at Newcastle used for iron ore storage purposes being completely filled, also to iron ore now in stock being more than sufficient to complete orders for steel which the company have on books, they have decided to cease quarrying ore at Iron Knob.

THE MINISTERS OF HEALTH and Labour have jointly appointed an inter-departmental committee to consider the relations of health insurance and unemployment insurance, and to investigate the possibility of reducing the total cost of administration by modifying the unemployment insurance scheme, and by amalgamating unemployment and health insurance cards, and, as far as possible., administration.

MR. R. C. CAMERON, iron and steel merchant, 84, Queen Street, Sheffield, who was formerly with the Frodingham Iron & Steel Company, Limited, has been appointed sole selling agent in the Yorkshire district, by John Lysaght, Limited, Normanby Park Steelworks, Scunthorpe, Lincs., for their basic steel billets, blooms, and slabs, also in the Sheffield area for the sale of the company's basic, foundry, and forge pig-iron.

THE WORTHING TOWN COUNCIL have accepted the tender of Mirlees, Bickerton & Day, Limited, of Stockport, for plant for the electricity works at a cost of £11,375. German tenders were £4,000 less.

MR. A. R. FINDLAY, 17, Robertson Street, Glasgow, sole Scottish representative of S. A. Daniell, Limited, Lion Works, Birmingham, has relinquished that position. Mr. S. Rowland has been appointed to succeed him.

THE APPLIED SCIENCE DEPARTMENT of the University of Sheffield has instituted a series of lectures on foundry practice. The course will consist of eight lectures, of which six will be delivered by Dr. Percy Longmuir, a past-president of the Institution of British Foundrymen, one by Dr. W. H. Hatfield, and the last by Professor C. H. Desch. The opening lecture of the series was delivered on the 13th inst. by Dr. Longmuir.

CAPT. H. RIALL SANKEY and Brigadier-General Magnus Mowat, president and secretary respectively of the Institution of Mechanical Engineers, paid a recent visit to Swansea, and were entertained by the local section at the Swansea Chamber of Commerce. Subsequently, Mr. D. E. Roberts, the vice-chairman of the South Wales branch, presided over a short meeting, at which Capt. Sankey delivered a brief address.

"THE Steam Turbine Simply Explained" was the title of a lecture delivered by Mr Trevor W. Phillips, B.Sc. Honours (Engineering) London University, A.M.I.C.E., M.R.S.I., F.R.S.A., to the members of the Marine Engineers' Association at a meeting held in the Branch Rooms, 11, Lord Street, Liverpool. Mr. A. C. Cockburn presided, having been elected president of the Liverpool branch for the ensuing year prior to the lecture.

IN THE absence of Mr. R. T. Hughes, the president, who is in France, Mr. T. Metcalf, vice-president, occupied the chair at the annual meeting of the North of England Association of Iron, Steel and Metal Merchants, held in Middlesbrough. The report of the Executive Council for the year ending December has already been published, and the report of the treasurer (Mr. T. R. Mackendrick) showed the finances of the Association to be in a satisfactory condition.

AN informal meeting of the Institution of Engineers and Shipbuilders in Scotland will be held in the Lesser Hall of the Institution, Glasgow, on Saturday, February 25, when a paper entitled "Gas Furnaces in Shipbuilding," by Dr. E. W. Smith, will be read. Among other matters the paper will deal with the discussion of fuels available in shipbuilding operations, the advantages of gas heating, the surface combustion principle, rivet heating, plate, etc.

THE second annual report of the British Non-Ferrous Metals Research Association, the headquarters of which is 71, Temple Row, Birmingham, has just been issued to members. Since the last report was published there has been a large increase in membership, over 100 firms now subscribing to the Association. The researches in progress at the present time are being conducted in the principal institutions and are of very varied character, some being of fundamental importance to the industry and others of immediate practical utility. At the National Physical Laboratory, Dr. Rosenhain is conducting an investigation on the effect of impurities up to 1 per cent. on the working properties of copper, which promises to form a permanent foundation for a fuller knowledge of copper and its alloys. At Manchester, Prof. F. C. Thompson has in progress work on the behaviour of nickel-silver alloys, and at Birmingham Professor Turner is examining the cause of red stains and smears on the surface of finished brass, a phenomenon which causes considerable trouble in the brass trade. The electric melting of non-ferrous metals has hitherto received less attention in this country than in the United States, and it is gratifying to see that that important matter is not being neglected. The Association is co-operating with several other like bodies in an investigation on metal polishing and grinding, and another piece of work in progress is that on the jointing of metals, including soft soldering, brazing and welding both gas and electric. The interests of members concerned with aluminium are also receiving attention. From the point of view of the non-ferrous trade the most important research is that being undertaken on casting, which is fundamental to all other forms of manipulation of metal. The existing knowledge of the members is being "pooled," and a thorough investigation is proposed with a view to placing beyond all doubt the conditions which result in the production of sound brass casting, commencing with strip casting. The Association may be congratulated on the results of its year's working, and bids fair to become one of the strongest bodies of its kind in the country. While the total results of researches are confidential to members, it is reassuring to buyers of British material, both at home and abroad, to know of the systematic study by co-operative effort in the improvement of non-ferrous metals, for only in this way can the advances now being made in Germany and the United States be met in competing for international markets.

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IRON AND STEEL MARKETS.

Pig-iron.

The slight improvement previously noted in the conditions of the pig-iron trade continue well maintained in the Cleveland market, and even in the Midlands, where recently business has been extremely quiet, a steadier and firmer tone is observable, buying being reported as a little better than of late. In the Lancashire districts, however, recovery is much slower, and although Northamptonshire forge is on offer on a basis of 75s. f.o.t., it is difficult to trace much actual business eventuating in that quality, nor in Derbyshire No. 3 foundry at the relatively cheap rate of 85s. f.o.t. There is now a better prospect of a revival of the foundry trade in Manchester and district, due probably to diminished Continental competition, and this will necessarily mean an early expansion of demand for pig in the local market. On Tees-side smelters are well booked up with orders over the month end, and in some cases are declining to quote on forward account. Scotland is reported to be still receiving deliveries of foreign pig, on account probably of uncompleted contracts, but Cleveland iron is also going in that direction in increasing quantities. In this connection it is interesting to note that for the first time since December the shipment of Cleveland pig-iron from Skinningrove to Grangemouth has been resumed. But it is not merely in the home trade that business is expanding. The demand from the Continent is also rapidly improving, and the February shipments abroad are on a much more substantial scale than for months past. Another cargo of 1,500 tons of Cleveland foundry pig was shipped to Germany last week, whilst Belgium is also buying pretty freely. The makers adhere to the official prices for Cleveland iron, viz., No. 1 and silicious, 95s.; No. 3 Cleveland G.M.B., 90s.; No. 4 foundry, 87s. 6d.; and No. 4 forge, 82s. 6d., but mottled and white is still on offer at about 75s. per ton.

East Coast hematite makers are also experiencing a good demand, but the steadily rising price of coke has led to a stiffening of quotations, and whereas at the beginning of the month mixed numbers were available at 92s. 6d, makers now refuse to accept less than 97s. 6d. per ton, with No. 1 at 98s. 6d., and in some cases they are indisposed to quote at all.

Finished Iron.

The recent reduction in the price of South Staffordshire marked bars to £14 10s. has not, so far, resulted in any great expansion of demand for this class of material, but is noteworthy as establishing a record total fall of £19 in values in practically a twelvemonth, an event unprecedented in the history of the industry. Makers now state that their reductions have actually exceeded the decrease in the cost of production, and that marked bars must be included among the list of unprofitable iron manufactures. Crown bars are also difficult to dispose of at more than £12 per ton delivered, while commoner qualities of this material are on offer at £11. Opinion in trade circles is expressed that steel competition for such material as cable iron is becoming more accentuated, and this is also experienced in the market for iron scrap, which is undercut by the prices now quoted for the steel substitute. In Scotland, bar iron makers are still finding difficulty in getting specifications, though the reductions made recently have helped, and are likely to continue to help them somewhat.

Scrap.

The various markets for scrap material continue somewhat patchy, dealers, as a rule, refraining from pressing sales at the prices now prevailing. The general quietude in the consuming industries is without improvement, but here and there some selling is recorded of the better quality metals. At Middlesbrough, steel scrap to ordinary specifications realises 50s., while for special material, mainly shipyard shearings, as much as 62s. 6d. is obtainable. Steel turnings are in fair demand at 42s. 6d. Cast-iron borings have been sold in small quantities at 40s. to 42s.

Steel.

The prospect in the Sheffield steel trade is for the moment without any tangible improvement, many of the leading manufacturing firms reporting the continued lack of specifications, and while here and there some show of activity is observable, the official unemployment returns mark a slight increase in the number of workpeople affected. Demand for the better class products of the steel industry remains quiet, but more open-hearth furnaces are being relighted, and some of the rolling mills are restarting operations. Inquiries for railway requirements are also said to be encouraging, and it is anticipated that shortly some good orders for rails, tyres, springs, etc., will be placed in the district. Semi-products show a weaker tendency, notwithstanding recent price cutting, and while Bessemer acid billets remain at £12 10s.. Siemens acid have been reduced £2, making the price £10 to £11 delivered, giving an unusual disparity between Bessemer and Siemens. Hard basic billets are £9 5s., and soft ditto, £7 to £8. By returning to the fixed minimum the Scottish makers have reached a higher level than was obtainable when ship-plates and angles were free of control, but this movement has brought in very few orders, and has possibly done more harm than good, as it is understood that the placing of some shipbuilding work has been postponed as a consequence. Ship-plates ($\frac{3}{8}$ in. and up) are now quoted £10 10s. per ton, and sections £10 per ton delivered at consumers' sidings or stations. Steel sheets are in quiet demand notwithstanding the price reduction recently intimated, which brought 3-15 in. to $\frac{1}{8}$ in. to the level of £11 15s. per ton, and into line with the steelmakers' quotations.

Tinplates.

Business in the tinplate market of late has been almost entirely confined to hand-to-mouth transactions, with buyers limiting purchases to actual immediate requirements. Prices for the basis sizes in coke finish may be quoted: I.C., 14 x 20, 112 sheets, 108 lbs., 18s. 6d. to 19s. per box; I.C., 28 x 20, 112 sheets, 216 lbs., 37s. 6d. to 38s. per box, f.o.b. Wales, according to delivery, spot plates, as a rule, commanding slightly higher figures than March/April. The demand for wasters is quiet and prices are inclined to droop. Current rates are about as follows: C.W., 14 x 20, 108 lbs., 17s. 6d. to 17s. 9d. per box; C.W., 28 x 20, 216 lbs., 35s. to 35s. 3d. per box; C.W., 14 x 18¾, 110 lbs., 18s. 9d. per box, f.o.b. Wales.

Metals.

Copper.—The depression from which the metal markets have been recently suffering shows no present sign of lightening, and in connection with standard copper has been accentuated by the fluctuating state of American quotations. Demand for home consumptive purposes is still poor, and buying of late has been almost entirely limited to small parcels for actual and immediate requirements. Values accordingly showed a further weakening tendency at this week's opening market, and under substantial offerings of March metal prices for standard closed 37s. 6d. lower for both cash and three months. Refined descriptions were also affected, closing with electrolytic 30s. to 20s. down at £64 10s. to £66 10s., and wire bars £65 10s. to £66 10s. Closing prices:—Cash: Wednesday, £60 2s. 6d.; Thursday, £60 10s.; Friday, £59 17s. 6d.; Monday, £58; Tuesday, £58. Three months: Wednesday, £61 2s. 6d.; Thursday, £61 10s.; Friday, £60 17s. 6d.; Monday, £59; Tuesday, £59.

Tin.—Markets for this metal developed further weakness at Monday's opening, heavy realisations and an adverse statistical position with regard to increased stocks in hand tending to shake confidence in an early recovery in values. Offerings on forward account have of late been unusually heavy, with persistent selling pressure, and this, combined with a substantial falling off of consumptive demand for the Welsh tinplate works, has had a depressing effect upon business. March dates were done at £146 10s. to £147, to £144 5s.; April, £147 10s. down to £146; and May, £147 15s. down to £148 5s., closing £146. English ingots were also weaker at £143 5s. London tin stocks are 152 tons lower on the week at 4,871 tons; Liverpool also showing a decrease of 96 tons with 1,808 tons. Closing prices:—Cash: Wednesday, £149 5s.; Thursday, £149; Friday, £148; Monday, £144; Tuesday, £140. Three months: Wednesday, £151; Thursday, £151; Friday, £150 5s.; Monday, £146; Tuesday, £141 17s. 6d.

Spelter.—During the past week prices for spelter have been subject to fluctuations and on balance quotations are easier. While the Continent is not selling at the prices ruling here, opinion is divided as to the probability or otherwise of American shipments to this side in the immediate future. Closing prices:—Ordinary brands: Wednesday, £24 7s. 6d.; Thursday, £24 7s. 6d.; Friday, £24 7s. 6d.; Monday, £24 10s.; Tuesday, £24.

Lead.—Conditions in the market for soft foreign pig have undergone little change since last reported, business on the whole being quiet, with an easier tendency in quotations. English closing prices: Wednesday, £21 15s.; Thursday, £21 15s.; Friday, £21 10s.; Monday, £21 10s.; Tuesday, £21.